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JOURNAL

OF THE INSTITUTION OF ELECTRICAL ENGINEERS

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THE INSTITUTION OF ELECTRICAL ENGINEERS

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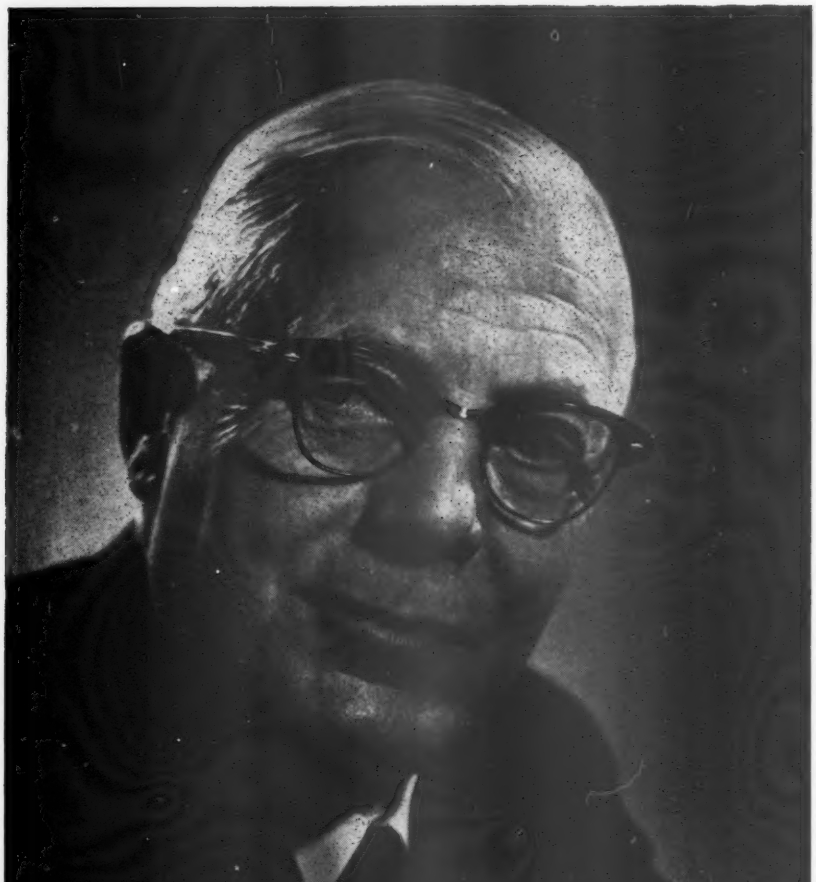


T. E. GOLDUP PRESIDENT 1957–1958

JOURNAL

OF THE INSTITUTION OF ELECTRICAL ENGINEERS

VOLUME 4 NUMBER 37 JANUARY 1958

THE PRESIDENT'S NEW YEAR MESSAGE

ONE OF THE MOST IMPORTANT EVENTS of 1957 was the inauguration of the International Geophysical Year, and there is little doubt that the discoveries which will result, and the new knowledge which will emerge, will provide untold opportunities for increasing our information about the world we live in, thus adding to our general scientific knowledge, which will eventually make possible an improved standard of life for all mankind.

But the I.G.Y. also has implications in terms of human relationships, which could, in the long run, prove far more important than the new knowledge it will bring.

It is most significant that, for the purpose of the I.G.Y., no fewer than fifty-six nations have come together in willing co-operation. Not only are the most eminent scientists of each nation personally bending their efforts to the common task, but they are doing so with the approval and encouragement, and even with the material support, of their respective governments.

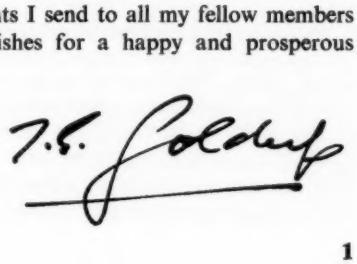
To my mind this proves beyond all doubt that it is possible for the human race, without distinction of colour, creed or nationality, to join in full co-operation to serve a common purpose. This fact, in my firm belief, promises the ultimate realization of the desire for world peace which all nations share.

There are, however, other lessons which we, in this country, can learn from this great example of co-operation for the common good. Very frequently the real difficulties underlying our national problems spring from the fact that those concerned are not fully or accurately informed of the true facts. Now, to enable the full benefit of the I.G.Y. to be reaped, the observations in all scientific fields made by those taking part will be sifted, collated and appraised by scientists trained in the techniques of analytical study, logical thought and strict impartiality, and the results will then be published for the information of all. It seems to me that an important factor in solving our internal difficulties must be to disseminate accurate information, simply expressed, about scientific, technical, industrial and economic matters in general. In this task the members of our Institution have a most important part to play, for it is to us that the layman will increasingly look to explain the significance of the many new advances to which our work is contributing.

But the example of the I.G.Y. goes further than this, for it demonstrates not only the possibility, but the actual existence, of a spirit of international co-operation on a global scale; surely it must be equally possible for all sections of our nation to co-operate in finding the solution of our many problems. Indeed, unless we can learn to live together as a nation where individuals are prepared to work sincerely for the common good and settle disagreements without resort to methods which damage our economy and disregard the convenience of others, we shall never be worthy or capable of playing our role on the international stage. By the same token we shall have no right to participate in the many benefits which engineering science has so lavishly showered upon the world.

We have achieved a very large measure of concerted effort within our own corporate body and also in our national scientific work; the I.G.Y. has proved that co-operation is possible internationally, between men of the most diverse opinions and interests. As we enter this new year of 1958 let us hope that these examples may help to secure the same concerted efforts within our social and political structure, and thus sow the seed for an ultimate harvest of peace, goodwill and prosperity for all.

With these thoughts I send to all my fellow members my sincere good wishes for a happy and prosperous New Year.



THE PRESIDENTIAL ADDRESS

Background, Foreground and Horizon

The following is a shortened version of the Address delivered by Mr. T. E. Goldup, C.B.E., on his inauguration as President of The Institution on the 3rd October 1957 (see p. 6). The complete text and illustrations will appear in both Part A (February 1958) and Part B (January 1958) of the Proceedings.

THERE is not one of us, I am sure, who does not look with pride on 1871 as the most significant year in the history of electrical engineering, for in that year this Institution came into being under its original title of 'The Society of Telegraph Engineers'. In recalling the state of science at that time, it is interesting to note that in that same year James Clerk Maxwell was appointed the first Professor of Experimental Physics at Cambridge, where he propounded his theories of the electromagnetic nature of radiant energy, and founded the Cavendish Laboratory.

Now, less than a century later, the original tale of some 70 members of The Institution has increased to more than 40000, and they have elected a President whose working life has been spent in a field described to-day as light electrical engineering and on a highly specialized subject, the threshold of which had not then been crossed.

Our Royal Charter requires us as an Institution 'to promote the general advancement of electrical science and engineering and their applications', and 'to facilitate the exchange of information and ideas on these subjects' amongst members of The Institution. The whole Institution is devoted to this end, an important part being played by the Local Centres, Sub-Centres, the Oversea Branches and Joint Groups. Important and necessary as all this is, it is the collective effort of individuals which matters, and it is a fact that this collective effort comprises the efforts of only a relatively small number of members. Each of you should consider whether your individual contribution to The Institution and to the development of the science in which you practise is as great as you feel it should be.

The coming generation of engineers will be responsible for maintaining our present leadership, and they must recognize that disaster will eventually overtake us unless they match new knowledge with increased wisdom.

My main theme to-night is thermionic valves, a subject which has constituted my life's work, first for a few years in the sheltered atmosphere of an Admiralty research establishment and then in the hard but exhilarating school of industry. I shall sketch my picture on broad canvas and will confine my references to a few aspects which I consider of interest and which are unlikely to be familiar to those of you who do not work in the valve field.

Background

On the 16th November 1954, The Institution celebrated the Jubilee of Ambrose Fleming's invention of the thermionic valve by a series of lectures and an exhibition. The proceedings of this memorable occasion are recorded in an Institution publication, 'Thermionic Valves 1904–1954', which provides an adequate history of the progress achieved up to that date. This progress is an example of combined operations involving the physicist, chemist, metallurgist, electrical engineer and mechanical engineer.

Foreground—Plant and Production

It is, strangely enough, most difficult to high-light specific technological achievements. So far as manufacturing technology is concerned, there have been advances on the broad fronts of chemical and mechanical engineering, combined with a strict control of raw materials and processes.

As a stage in the chain of events leading from research and development to a manufactured article, the importance of plant design and development is paramount, for they are prime factors in the economics of production and only through economic and efficient production can industry finance research, development and all its other activities. Additionally, plant design determines very largely the actual manufacturing processes to be used and how far modern technological advances can be employed. Looking at the achievements since valve manufacture started after the First World War, I regard factory plant design as the hub from which have stemmed improvements in productivity, quality and quantity, the introduction of modern technological processes and the inspiration for achieving the almost impossible in the complex chemical and vacuum processes which are involved.

An indication of the extent of this relatively new industry is given by the following figures. In 1956 the turnover of the British valve industry was £25 million and it produced sixty-four million valves of all types and over two million cathode-ray tubes. These figures represent more than a threefold advance on those for 1949, and there is no doubt that the trend towards increased production will continue.

The Changing Scene—New Developments

Change has been the essence of valve development from the time of Fleming's early work, and a great volume of research has always been undertaken in the valve industry. As I cannot mention more than a fraction of the whole, I have limited my remarks to a few outstanding examples, and more particularly to three types of device—microwave valves, special-quality valves and semi-conductors—and have avoided detailed technical considerations which would be inappropriate in an Address such as this.

I have chosen these three more particularly on account of the interest displayed in them by the Government for national needs. During the war the Inter-Services Committee for the Co-ordination of Valve Development (C.V.D.) came into being, its task being to foster and take the responsibility for valve developments for applications in equipment used by the Armed Forces, and to ensure that the various Services should not be competing for the limited technical resources then available to the valve industry.

The work of C.V.D. has continued and has increased many times. C.V.D. organizes effective liaison with the valve industry, maintains close touch with development results, and has prepared a balanced pattern of development projects. C.V.D. sponsorship of these has been a major factor in keeping Britain in the van of progress.

Microwave Valves

One important development in microwave valves is the availability of cathodes having high emission current-densities. An example is the dispenser-type cathode pioneered by Lemmens, in which the emissive material percolates to the surface of a porous tungsten body when the cathode is heated.

The magnetron was originally conceived by Randall, Boot and Sayers at Birmingham University, and was rapidly taken up by America. Its main applications are in pulsed radar, and British manufacturers supply the major part of the world demand for marine radar equipment. Other radar applications are airborne sets for warning against cloud and collision, and radar control of ground movements on airport runways.

The magnetron has been extensively used as a source of radio-frequency power for linear accelerators—devices in which electrons are accelerated to very high energies. Originally developed as an atomic energy research tool, it was later used for medical, radio-therapy and X-ray purposes, and more recently in the plastics industry for irradiating polyethylene, thereby improving its heat-resisting properties. A limited application of the magnetron is as a source of power for radio-frequency cookers.

The klystron, developed in its reflex form as a local oscillator for superheterodyne receivers, originated in America, but British work in this field during the war included valuable contributions by Sutton and his team at Bristol, and by the Clarendon Laboratory. Types are now available for operation at wavelengths down to 2 or 3 mm.

Amplifier klystrons are now finding increasing application in radar and particularly in phase-coherent radar, in which the reflected pulse from a target is compared in phase with the transmitted pulse, the resulting beat frequency being a measure of the target velocity. A common factor in all variants of the phase-coherent radar system is the need for improved microwave amplifying valves. Klystrons with pulse powers of the order of megawatts are now possible, and, in the lower-power types, gains of more than 100 dB have been achieved. The amplifier klystron is also coming into extensive use in navigational aids and for television transmission in Bands IV and V.

The travelling-wave tube, first developed by Kompfner while working for the Admiralty, has received concentrated attention during post-war years. In this tube a wave is caused to travel slowly along a structure such as a helix, and a beam of electrons travels at almost the same velocity and in close proximity to the wave. The electron beam interacts with the wave, which is amplified, the additional energy being derived from the kinetic energy of the electrons which are slowed down in the process. By special treatment of the electron beam, the noise due to random velocity and density of the electrons can be largely removed. The low noise factor, the high gains and broad bandwidths obtained with this tube have led to its adoption for use at centimetric wavelengths for radio relays and for telegraphy, telephony and television.

In addition to the comparatively low-power travelling-wave tubes required in communication, tubes of really high power are under development. I believe that eventually some communication will be carried out by the propagation of millimetric waves along small-diameter waveguides; the success of this development will depend on the provision of suitable travelling-wave tubes to act as practical oscillators and amplifiers.

The International Microwave Valve Convention, to be held under the auspices of The Institution in the spring of 1958, will be of considerable importance in placing on record the huge volume of work which has been achieved in this field.

Special-Quality Valves

When, during the war, new applications for valves arose, such as for airborne radar, the valves incorporated were at first those based upon the design requirements of the domestic entertainment market. These valves were not primarily intended to withstand the severe mechanical conditions associated with the new applications, and the need arose for a series of valves whose characteristics would not be impaired nor their life shortened by these arduous conditions.

With the support of C.V.D., British valve manufacturers set out to meet these requirements. Intensive study of the properties of the materials used, of the fatigue behaviour of glass, metals and mica, of the effects of static stresses within the valve and of cyclic stresses externally, was undertaken. The causes of the deteriora-

tion of the electrical properties of valves were investigated, and existing methods of manufacture were critically reviewed.

All this, and the development of sub-miniature valves for use in missiles, has added greatly to our knowledge of valve manufacturing technology, and has resulted in the production of several types of special-quality valves, manufactured in air-conditioned plants under conditions similar to those obtaining in the manufacture of pharmaceutical products.

Semi-Conductors

Invented in 1948 at the Bell Telephone Laboratories in America, the first transistor was of the point-contact type. Theoretical considerations pointed the way to the more sturdy junction transistor, of which the first prototype was made in 1951. The transistor is an amplifying device, with a wide field of applications on account of its miniature size and the small amount of power required to operate it, and is destined to have a profound influence on the design of such apparatus as computers, repeaters, telephone exchanges and Service equipment.

Important progress is being made in developing transistors for use at ever higher frequencies. The theoretical limit seems to be in the region of about 1 000 Mc/s, and types operating at 10 Mc/s and over are already in production in America.

An effect analogous to electron multiplication in an ionized gas is the basis of a semi-conductor device for generating very-high-frequency oscillations, which may eventually reach the region of the centimetric waves.

The Maser is a semi-conductor amplifier which produces *m*icrowave *a*mplification by *s*timulated *e*lectromagnetic *r*adiation. Although capable of operating at low powers only, and having only low efficiency and bandwidth, the Maser gives a useful gain, and at the extremely low temperatures at which it must be operated its signal/noise ratio is extremely high.

The utilization of solid materials for electronic devices is so new that its full potentialities cannot at present be assessed, but it is possible that it may provide the key to the whole field of millimetric waves.

Automation

Attention is being focused on automation because, with the aid of electronics, we are now able to make machines which not merely assist our physical efforts but also augment our mental efforts. In this type of equipment sensing elements collect and feed back information, so that any departure from the desired results can be corrected. Machines can also be made to carry out a definite programme of operations or to react in appropriate ways to changing conditions. In the more complex systems electronic computers and electronic memories are incorporated.

The social implications of automation are highly important, for if they hinder its adoption technical progress is bound to be retarded. No other recent advance has been so misunderstood; if one considers the countless and complex functions the human brain can perform, one realizes that no machine could ever be a substitute. In addition, I cannot conceive that any machine will ever replace the relatively few geniuses upon whose vision and creative ability the evolution of our civilization depends. On the day man is content to leave all his imaginative thinking to machines he will be destined to a future without hope, without beauty and finally without love.

•

Entertainment: Radio and Television

It was on the enterprise and success of the entertainment section of the radio industry that the valve industry was founded. Furthermore, but for the existence of a large entertainment radio industry, radar sets and other Service equipment could not have been produced in the necessary quantities at the start of the last war.

In television, whether black-and-white or colour, development is centred mainly on the viewing tube. Tubes with electrostatic instead of magnetic focusing offer the advantages of reduced weight, easier setting up, and little or no variation of focus with changes in mains voltage. The successive increases in the deflection angle from 55° to 70° and now to 90° permit the use of a smaller, cheaper cabinet. The next logical step is a further increase to 110°.

While there have been a few applications of colour television, notably in the medical field, its use for entertainment still awaits the development of a far cheaper means of viewing. Cheaper tubes so far suggested invariably mean more complex and expensive circuit design, and it may be that the method of viewing finally adopted, not only for colour but for black-and-white, will differ greatly from what we might expect with our present knowledge.

Low-Temperature Devices

In its advance, electronics is constantly crossing the boundaries of new territories, as witness its fruitful association with ferrites and semi-conductors. Its most recent excursion is into the realm of low-temperature phenomena. Because of the extremely low noise level at temperatures near absolute zero, operation in this range holds great attractions for the electronic engineer.

One low-temperature device, the Maser, I have already referred to in dealing with semi-conductors. Another is the Cryotron—a switching device comprising a straight wire with a second wire coiled round it, the whole being immersed in liquid helium, and therefore having effectively zero electrical resistance. However, the resistance of the straight wire is restored if a sufficiently strong magnetic field is created by the coiled wire. This effect can be produced within microseconds, and the arrangement thus acts as a very-high-speed relay. It may well have wide applications in large computers.

Frequency Allocation

I attach supreme importance to the use of that irreplaceable raw material, the ether. The problems o

frequency allocation become more acute with every extension of radiocommunication. International agreement has, on the whole, been good, but some of us have doubted whether allocation at national level has taken the needs of all users sufficiently into account. The decision of the Postmaster General to set up a Frequency Advisory Committee to guide him on the broad aspects of frequency planning is therefore welcome.

Education and Training

Because our future progress, industrially and therefore nationally, depends upon the work of individuals of ability who possess the requisite learning and skills for the creation of new knowledge and the development of new technologies, the importance of the individual cannot be over-emphasized.

Some progress has been made in the task of greatly increasing the number of adequately trained scientists and engineers, but much still remains to be done, and I want to use this opportunity to suggest some lines of action which I believe to be necessary.

In the first place the training of the potential scientist must include sufficient liberal studies to make him aware of the social and economic problems of the modern world, while the potential classics man must acquire more general science knowledge so that he can understand the effects of scientific advances.

To achieve this, the level of science teaching in secondary schools must be raised, and should begin at an earlier age. This demands many more trained teachers, and possibly an extension of the period spent at school. Other lines of approach include the introduction of non-faculty subjects in university entrance examinations, which in turn would require changes in the present accepted G.C.E. subjects at the advanced level. Some practical support for this idea would be given by the suggested Cambridge honours course combining science and the arts.

The problem of the supply of teachers in technical colleges is summed up in the recent report of the special committee, under the chairmanship of Dr. Willis Jackson, appointed by the Minister of Education. This report states that the teaching staff as at 1955–56 should, by 1960–61, be increased by 7100 full-time and 8000 part-time teachers. The report also states that educational institutions and industry tend 'to regard themselves as separate and distinct rather than as intimately associated partners in a joint enterprise', and urges that industry 'must be willing to accept and, indeed, to encourage and assist, the transfer to full-time teaching work of experienced staff it can ill afford to lose'.

I should like to impress upon the electrical industry the need for a better understanding of the importance of industrial training as part of the sandwich courses now being approved by the National Council for Technological Awards. Run by approved technical colleges, these courses will lead to the Diploma in Technology (Engineering), and the successful student will be considered knowledgeable in both the fundamentals of science and technology and in the practical application of that knowledge. It is vital, therefore, that the periods of industrial training should never be regarded merely as periods of normal employment unrelated to the academic part of the sandwich course. Industry must take an active part in determining the standards and requirements of the technological training and must insist on those standards being maintained.

The burden of practical training is at present almost exclusively carried by the larger industrial concerns; but there is a limit to what these organizations can do, and although this limit may not yet have been reached, it is clearly right and necessary that smaller firms should contribute to the pool of practical training facilities.

Another problem in the field of technical education is that of keeping technical personnel up to date with the many new ideas which are constantly emerging. The normal method of keeping in touch with progress is by reading and by outside lectures, but sometimes a new concept calls for some other approach. Transistors, for example, demand from the engineer entirely new habits of design thought, and industry must then re-educate its own engineers. In the case of transistors this need has been met, in one instance, by the production of a film which first explains the theory of transistor operation and then proceeds to the derivation of the equivalent circuit. Such an approach enables the engineer to build his ideas on the solid foundation of fundamentals.

Recently the recruitment of larger numbers of women to the ranks of technicians and professional engineers has been increasingly advocated. Such a course presents its own peculiar difficulties and requires a change in outlook among teachers and parents and by industry. But we urgently need the contribution which I am quite sure suitably trained women can give, and it is high time that we ceased to fear the shadow which the wedding ring casts before and behind it.

The Press

I am glad to be able, in this Address, to make some acknowledgment to the Press, both technical and lay, to whom The Institution and the electrical industry owe so much. It is important that the public be still more informed on scientific achievements so that they are better able to recognize the significance of our work as engineers. This is the field of the lay Press, and we are grateful to them for the work they have already done. I am certain that the role they are playing in this way will be of ever-growing importance.

The technical Press plays a major part in bridging the gap between the specialist and his ignorance of other work which has no immediate bearing on what he is at present doing. We also look to the technical Press for the broad and intelligent exchange of ideas and information, and for the publication of the results of individual work. I like to think of the technical Press as complementary to the journals of the learned and professional institutions, the whole constituting a shop-front in which we can display our scientific wares.

Beyond the Horizon

Possibly the most significant issue which members of professional bodies such as our own will have to face in the future is their role as leaders—not merely as leaders fit to hold executive positions, but as leaders who accept responsibility for so guiding public opinion that modern scientific and engineering advances shall be applied to improving the well-being of mankind rather than the reverse.

Hitherto we have concerned ourselves almost exclusively with the establishment of scientific truths, with putting new knowledge to practical use, with producing some commodity at the right price, at the right time, and in the right place, and with showing how engineering science can be successfully harnessed to supply our many needs. With very few exceptions we have been little concerned with the social and political repercussions of our efforts; the use which others make of our work has far too seldom appeared to us to be of prime importance. I believe, however, that the time will soon be here, if it has not already arrived, when more of us must be as much concerned with the results of our achievements as with the work itself.

For instance, what is our responsibility for the social changes which automation will bring? Again, have not the engineers who have created television some special responsibility for the way in which this medium is used? They surely cannot stand aside and make no contribution whatsoever to current thought on these matters. The scientist must take part in government at the highest level, as exemplified by the appointment of the late Lord Cherwell by Sir Winston Churchill as his scientific adviser during the last war.

However, it is in the military sphere that the question of our responsibility has appeared in its most acute form. Writing in 1945, in the first report ever published on the military use of atomic energy, H. D. Smyth of Princeton University, New Jersey, said:

> We find ourselves with an explosive which is far from completely perfected. Yet the future possibilities of such explosives are appalling and their effects . . . on international affairs are of fundamental importance. Here is a new tool for mankind. . . . Its development raises many questions which must be answered in the future. These questions are not technical questions—they are political and social questions, and the answers given may affect all mankind for generations.

We are very little nearer to finding an answer to these questions to-day than we were twelve years ago when this was written.

Meanwhile we now have a completely new situation. The world has been brought to a crossroads; one road leads to the destruction of world civilization as it now exists, the other to a better life for everyone—not only for those in backward countries but in highly developed countries too. It is we, the engineers and scientists, who are largely responsible for this position, and surely we are morally responsible for the way in which our work is used. Can we, or dare we, stand aloof from the social and political implications of what we have achieved? I am convinced that this question must sooner or later be given an answer. I am equally convinced that this great Institution of ours has a vital part to play in framing that answer.

The Opening Meeting

The inauguration of Mr. T. E. Goldup as President

A report of the Ordinary Meeting of The Institution at Savoy Place on the 3rd October 1957, at which Mr. T. E. Goldup, C.B.E., succeeded Sir Gordon Radley, K.C.B., C.B.E., Ph.D.(Eng.), as President of The Institution. A shortened version of Mr. Goldup's Inaugural Address appears on p. 2.

THE Opening Meeting, more than any other in the session, has about it the air of an occasion. An impressive attendance of members fills the tiered benches to capacity, with here and there a bright touch of colour provided by the ladies, while the presence of distinguished guests contributes to the pleasant formality of the evening. The solidarity of the profession is very

Dr. T. Ingledow receives a Premium Certificate from Sir Gordon Radley at the Opening Meeting for his work on the British Columbia-Vancouver Island submarine power cable

Mr. T. E. Goldup delivers his Inaugural Address

apparent, and the imposing portraits of famous engineers which look down from the panelled walls seem to unite the diverse specialists in a common history and a mutual purpose. The traditional ceremony is permeated with a quiet and friendly dignity of its own. The design of the lecture theatre, with its curved rows of benches sloping to the very foot of the rostrum, seems to include the senior Members of Council with the general body of members, so that those officers appear not as remote leaders but rather as experienced and friendly advisers. The Presidential Address and the ensuing speeches echo and amplify, with depth and humour, this feeling of warm fellowship.

The new President, **Mr. T. E. Goldup,** is an engineer of wide experience in the manufacture of light electrical components, and the main theme of his Address was the development of the thermionic valve, with which he has been associated all his life.

Sir Gordon Radley, the retiring President, took the chair at 5.30 p.m., and after announcing the donations and subscriptions to the Benevolent and Homes Funds he conducted the customary ceremony of welcome to new Corporate Members. He congratulated the thirty-one members and presented each with a bound copy of *The Institution: Its Objects and Organization.*

This ceremony was followed by the annual presentation of Premium Certificates.

An unusual feature of this year's meeting was the presentation of inscribed leather-bound copies of the *Symposium of Papers on the Transatlantic Telephone Cable* to the British authors of papers read at that Symposium. This recognition of a great engineering achievement was appreciated by the audience, who greeted the authors with loud applause as they came forward to receive their copies from the Chairman. There was general laughter as well as sustained applause when Sir Gordon was faced with the Alice-in-Wonderland task of presenting one of the copies to himself—as one of those mainly responsible for the successful laying of the cable.

Sir Gordon then welcomed Mr. Goldup as the new President and called upon him to deliver his Presidential Address. It was most instructive and entertaining, and it was unique in being the first Presidential Address before The Institution to make use of cinematograph films. Two films were shown, the first illustrating the progress in techniques in the manufacture of thermionic valves, and the second comprising animated diagrams of the mechanism of semi-conductor devices. The first film had a commentary in sound by Mr. Goldup himself, so that the continuity of the Address was preserved while the film was being shown.

The Address was received very warmly by the audience, and when the applause had subsided Sir Gordon Radley called on **Sir Noel Ashbridge** to propose the vote of thanks to Mr. Goldup. Sir Noel said that there was no need for him to stress how interesting and well constructed the Address had been. The major task of an incoming President is to decide what he is going to take for the subject of his Address. Very often, having made a choice of a subject and having written perhaps the first thousand words, he finds that everything flows fairly easily. It was quite obvious that Mr. Goldup's Address flowed smoothly and easily from start to finish. Sir Noel was glad that Mr. Goldup chose to describe the thermionic valve more fully than transistors or semi-conductors, because the valve had not, curiously enough, been very widely dealt with by The Institution.

Sir Noel supported the reference to technical education that had been made in the Address. He did not mind how much was said and written on that subject—attention could not be drawn to it too often. The situation was serious. Education was the life-blood of all engineering and technology generally, and if it was not taken seriously industry would fall back and our oversea trade would decrease. The more the subject was discussed, the better, so long as the discussion was constructive.

He then commented on Mr. Goldup's point that if we made computers with the same astronomical number of components as there are cells in the human brain several hundred would be out of action at any given moment. Sir Noel agreed with this, but he also thought that probably many of the cells in the human brain *were* out of action, and that the number was very much higher than hundreds. Sir Noel suggested apologetically that perhaps a good many of his own cells were not behaving well that evening!

In conclusion he said that he believed that Mr. Goldup had been right in drawing attention to the responsibility of scientists and engineers for the way in which their work was used. Whether The Institution could help in that matter, Sir Noel did not know, but he said that it must try to do so.

Sir George Nelson proposes a vote of thanks to Sir Gordon Radley

He had very great pleasure in proposing the following resolution: 'That the best thanks of The Institution be accorded to Mr. T. E. Goldup for his interesting and instructive Presidential Address, and that with his permission the Address be printed in the *Proceedings* of The Institution'.

The vote of thanks was seconded by **Mr. C. T. Melling,** who said that the Address had been an admirable one and had given a far sight of the whole field of electronic work. Mr. Goldup had taken his audience to the mountain top and shown them the horizon, but he had done more than that. He had taken them inside the mountain, or, rather, inside the thermionic valve during the course of manufacture, and if they had emerged breathless it was not because of the vacuum; it was because of the interest created by his most masterly exposition of a difficult subject. The fifty years of the electronic revolution had influenced a remarkable period, a period of great technological change. There had also been great changes in social life. Mr. Melling was reminded of a time when people sang a hymn about 'the rich man in his castle, the poor man at his gate', but he had heard the modern version of that stanza:

> The poor man views the castle,
> The rich man takes the gate.

He said that Mr. Goldup had pointed out the dangers of the present-day striving for technological improvements and efficiency. He had emphasized the importance of a liberal education and had touched upon the human and spiritual side as well as the technical. He had shown us the man, as well as the President of The Institution.

After the vote of thanks had been put to the meeting and carried with acclamation, Sir Gordon Radley said that it was his privilege to invite Mr. Goldup to take the Presidential chair as his rightful place. He then vacated the chair in favour of the incoming President, **Mr. T. E. Goldup,** whose first action was to call upon Sir George Nelson to propose a vote of thanks to Sir Gordon Radley.

Sir George Nelson said that it may seem a little sad that, in welcoming the new President, we put aside his predecessor, and he asked those present to pause a moment in the inaugural ceremony to say a valediction to Sir Gordon Radley and to look back over his year of office and see what he had meant to The Institution. He said that Presidents, in their coming and going to that high office, leave marks of their personalities upon The Institution; they establish new precedents and slightly vary old traditions. It seemed to Sir George a very short time since he inducted Sir Gordon into the Presidential chair. He had undoubtedly left his mark on The Institution, and members were glad that they would still have him to play an active part in the work of the Council.

Probably only a Past-President could fully appreciate the strain and demands made on the President, but those on Sir Gordon had been even greater than those on most Presidents, first owing to his illness in the middle of his year of office, and second by his simultaneously holding one of the most responsible positions in the national life.

One of the happiest events in his Presidency was the joint meeting with the Engineering Institute of Canada and the American Institute of Electrical Engineers, linked by the transatlantic telephone cable. That would have been a great event in any year, but the fact that Sir Gordon Radley himself had been the principal architect of the cable made it doubly significant.

Mr. R. J. Halsey is given a presentation copy of 'The Symposium of Papers on the Transatlantic Telephone Cable'

Sir George felt, however, that Sir Gordon's fame in connection with the transatlantic telephone cable had obscured what might in the long run be an even greater

claim to fame—namely, that of being the first electrical engineer to be the permanent head of a Department of State. Sir Gordon's undoubted ability and success in his position and the fact that he had carried out the heavy duties of President of The Institution while holding it deserved members' warmest praise.

Sir George was sure that a large part of the credit was due to Lady Radley, who had discharged her responsi-

Sir Gordon Radley receives a Certificate of Presidency from Mr. Goldup

bilities as a President's wife with grace and charm. On behalf of The Institution, Sir George thanked her for her participation in official activities and most of all for looking after her husband so well. He ended by formally proposing the motion: 'That the best thanks of The Institution be accorded to Sir Gordon Radley for the very distinguished and most able manner in which he has filled the office of President during the past year'.

Mr. S. E. Goodall rose to second the vote of thanks, saying that during his long 'course of training' for the Senior Vice-Presidency it so happened that it was not until the year before last that he had had the good fortune to work on a committee with Sir Gordon Radley. Then he had served with him on the General Purposes Committee, and last year had come into even closer collaboration with him on the Finance Committee. During the whole of that period his respect for Sir Gordon had grown as he came to appreciate his qualities of leadership and inspiration.

Sir Gordon had had an arduous year in the Post Office, but he had always been ready to help The Institution, both in London and at the various Centres, accompanied on many occasions by his gracious wife, Lady Radley; The Institution had been exceptionally well served by her charm and general demeanour, and by her courtesy to everyone she had met.

Finally Mr. Goodall expressed to Sir Gordon the sincere appreciation of the membership as a whole—and particularly of the Members of Council—for all he had done. He was regarded with affection, and his many excellent qualities had added much to the status of The Institution.

The President put the vote of thanks to the meeting and it was carried with loud applause. He then presented **Sir Gordon Radley** with the Certificate of Presidency.

Sir Gordon said that he deeply appreciated the very kind things that were said by Sir George Nelson and Mr. Goodall. He felt that in some cases they were very wide of the mark, because he had not been able to do half the things that The Institution was entitled to expect of its President. As the role of The Institution in the national life became more important the limitations to what Presidents who had other responsibilities could do would become more of a problem.

He went on to compare Mr. Brasher's function in The Institution with that of a Permanent Secretary of a Government Department. Both had to steer a succession of elected Heads. The Institution owed its steady progress in stature during the post-war years to what had been done behind the scenes by Mr. Brasher, who had steered Sir Gordon during the past year, as he had steered previous Presidents, ably assisted by his secretariat.

Sir Gordon thanked the members of the Local Centres for the very friendly welcome they had accorded him and his wife. The happy time they had had at the Centres was one of the memories he would take with him from his year of office.

Finally, Sir Gordon Radley thanked his wife for having kept him going and for bearing with him when he was absent on Institution business and often when he was present in body but absent in mind. He wished Mr. Goldup every success in taking up the many tasks which he, Sir Gordon, had just laid down.

The President then declared the meeting closed.

STANDARD TERMS: ENGINEERING AND BIOLOGY

'The advantage of the electrical engineer's attention to words, an attention that, it will be remembered, began with Faraday, becomes apparent at conferences and committees. Among electrical engineers, disagreements cannot arise through different meanings being given to the same words, as so often happens in other disciplines. The discussion of electrical engineers is centred on concepts, which is where it should be, and it is largely thanks to their standardized glossaries that they understand each other so readily. . . . I have occasionally commented to biologists on the number of confusing and conflicting words in their subject, on their lack of system in the formation of technical terms . . . on the wasted effort when an argument that purports to be about concepts is really only about the meaning of words . . . But when I say all this to a biologist his answer is that his subject is developing too rapidly to be forced into the strait-jacket of a standardized vocabulary. Though I point out that electrical engineering, too, is in a state of rapid development, he remains unconvinced. It is too soon for the standardization of biological terms, he tells me.

'He is right. It is always too soon to standardize anything—and it is always too late.'

—From Professor R. O. Kapp's Le Maistre Memorial Lecture delivered in Moscow at the Annual General Meeting of the I.E.C. in July 1957

TELEPHONE OPERATORS' ADAPTATION TO TRAFFIC VARIATIONS

This article describes some experiments on the performance of telephone operators that were carried out by the authors, under the auspices of the Medical Research Council, at the Thanet auto-manual cordless telephone exchange. Among other results established was that the average time taken by operators at the exchange to set up a call decreased linearly with the logarithm of the traffic per operator. The authors are with the Applied Psychology Research Unit at Cambridge.

R. CONRAD, M.A., PH.D.
BARBARA A. HILLE

Introduction

A good deal of human work requires a person to process items of material or information which comes to him at a rate which he does not himself control. The process might be selling train tickets, or assembling units on a conveyor belt, or rectifying loom stoppages, or setting up a telephone call in response to a particular kind of signal, or any of a great variety of kinds of human behaviour. There is then frequently the practical problem of determining the optimum rate at which to deliver the items to the operator so as to achieve a desired output level, or of determining the optimum number of operators to deal with an input which can be counted but not varied at will.

Common sense might initially suggest that, although within a series of like items some will take longer to process than others, the average processing time will not vary whether the items pile up in a growing queue before the operator, or whether there is regularly a long interval between them; that is, the operator deals with each item as it comes, the time required being unaffected by the frequency. There is the further advantage in this particular view that by applications of queueing theory it is possible to calculate the expected output of a system given the input rate and processing time.

Evidence is accumulating, however, that input rate and processing time are rarely independent; that people working in the conditions described above are sensitive to the input rate as a distinct feature of the system. There is, for example, a widely held belief that people will work faster in order to keep up with an increasing rate of occurrence of work. This phenomenon has been casually observed quite often, but the relationship has never been formally studied. On the other hand, one might consider that the proverb 'more haste, less speed' expressed the opposite view. Perhaps because the consequences might be more serious in practice, this latter effect has been sought and demonstrated in the laboratory.[1] Mackworth[2] too has drawn attention to the possibility of its presence in the control room of modern naval ships, whilst the harassing effects of over-fast work rates have been noted in telephone operators by le Guillant *et al.*[3] In fact it seems likely that both views are correct and that the type of work, and perhaps the type of person, determines whether faster or slower work will result from an increased input rate. But in neither case can one say that the quantities involved have been adequately determined.

These questions are pertinent to the problem of staffing operator-manned telephone exchanges, where the output might be expressed in terms of the delay encountered by subscribers waiting for an operator to answer. The classical work of Erlang, described by Brockmeyer, Halström and Jensen,[4] facilitated the solution of many of the problems involved in the provision of equipment at automatic telephone exchanges, and more recently Wilkinson[5] has shown that the derived formulae might be suitable for dealing with the staffing problems of manually operated exchanges. In his solutions, Wilkinson makes use of assumptions originally proposed as applicable for automatic equipment; the most important of them is that switching time is independent of traffic, or in the context of a manual exchange, that the rate at which calls enter an exchange does not affect the time taken by operators to deal with them. If this assumption is accepted and operator time known, the exchange can be staffed according to the quality of service required as measured in terms of subscriber delay.

In view of the doubt surrounding this assumption, the experiment described below was made to test its validity by systematically varying the number of calls per operator per unit time. This took place at the Thanet cordless exchange, a relatively small exchange serving part of the coastal area of Kent.

The Method Used

Predicting Traffic. Since a 10% sample of all calls entering the exchange was automatically counted, and continuously indicated on a meter, it was possible to make the main experimental variable the rate of work in terms of *calls per operator per hour*; the number of calls entering the exchange divided by the average number of operators on duty during an hour. The experimenter had no control over the number of calls made by subscribers, but could vary this rate by controlling the number of operators present to deal with them. The pattern of traffic change was such that it was worth while controlling the number

of operators at half-hourly intervals. This control clearly had to be exercised in advance of the actual traffic, the expected traffic being predicted.

A curve was roughly fitted to the daily traffic totals covering the dates of the experiment but for the previous year. It was provisionally predicted that the values on that curve would hold once again, and on those daily totals and on the changes expected during each day, staffing schedules were drawn up to meet the demands of the experimental design. But during the experiment the amount of incoming traffic was continuously monitored, leading to frequent modifications of the staffing schedule with very little notice. The volume of traffic during the first hour of a day, for example, often provided a guide as to the likely total for that day. But at any time departures from predicted levels had to be expected.

Classification of Data

Group	Calls/operator/hour		Number of hours
	Range	Mean	
1	20–23·9	22·5	11
2	24–27·9	25·9	29
3	28–31·9	29·6	21
4	32–35·9	34·0	28
5	36–39·9	37·6	21
6	40–43·9	41·9	29
7	44–47·9	45·9	12
8	48–55·9	51·2	8

N.B. One hour of work when the traffic level exceptionally rose to 65·3 was excluded from the data.

The Experimental Design. Ideally to describe the desired relationship, operators should have worked with a number of controlled traffic loads in a random order, with several replications to minimize transfer effects from one condition to another and balance out special effects due to working on different days of the week. But because of the influence of the many unpredictable factors which determine traffic loads, only an approximation to this ideal was practicable. In the event, over the four-week course of the study, the discrepancy between predicted and actual traffic loads was only 0·14%, but during any one day it rose to a maximum of 6·7%. The effect of this discrepancy was to nullify the value of the idea of a number of discrete traffic loads.

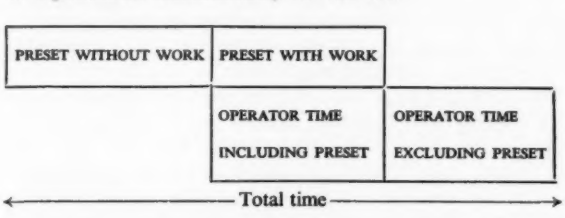
Accordingly, at the end of the experiment the data were considered as a whole, and were regrouped so that the traffic loads fell into eight mutually exclusive ranges irrespective of time of day or day of the week. These latter secondary variables were treated separately, statistical analysis indicating that the main results would be relatively little distorted by these particular factors since their effects were fairly evenly distributed. Regrouping the data in this way forbade the use of certain convenient statistical treatments of the results. It will, though, be shown that the main results are sufficiently clear without submitting them to precise statistical test. The table in the adjacent column shows the way in which the data were regrouped.

Throughout the following analysis of results, the mean values of calls per operator per hour shown in the table will be regarded as the main experimental variable.

Description of Terms. The time during which a subscriber waits for an operator to answer is the *time to answer* (TTA), and is one measure of the quality of service. The TTA of every tenth call was automatically counted, the summed value of successive counts being shown on a meter. The value of the average TTA over a period depends on the calls per operator per hour, the number of operators, the average operator time per call and the distribution of this latter time. Since the first two quantities can generally be given and the last is usually assumed to be constant in form, it can be seen that an understanding of the relationship between traffic and average operator time per call is essential for predicting the TTA for different traffic levels.

An operator's time can be clearly defined in three parts: (*a*) dealing with one call and unable to accept another; (*b*) dealing with one call, but the work such that she would be able to accept another; and (*c*) no work in hand at all and hence able to accept a call. In defining *operator time per call*, the purpose of the definition must be considered. From the viewpoint of predicting the TTA, (*a*) is the only relevant part. From the point of view of assessing idle or resting time, (*a*) and (*b*) must be added together.

When an operator is ready and available to accept a call whether or not she is still working on another, she *presets* her equipment, thus giving access to a call when it arrives. An operator can thus be preset with no work in hand, or preset and still working but ready to accept another call. For simplicity of definition, these states can be represented schematically as follows:



If operator time can be measured as a proportion of total time, an average value of operator time per call can be calculated as follows:

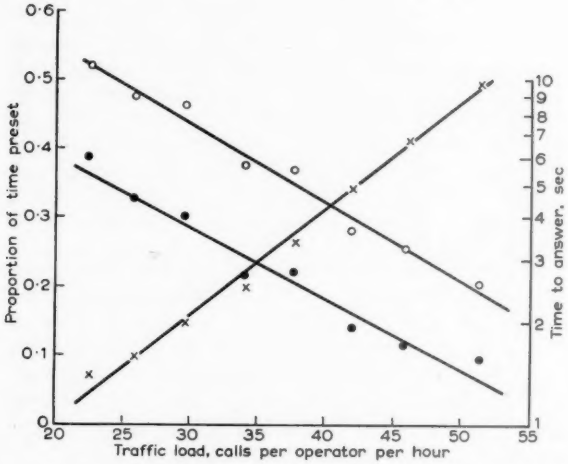
$$\text{Operator time per call (sec)} = \frac{(\text{Proportion of total time spent on operating}) \times 3600}{\text{Number of calls per operator per hour}}$$

Method of measurement. The snap-reading method described by Tippett[6] was used to measure the proportion of the total time spent in operating. Briefly, a number of independent observations of operators are made; these are recorded, and after classification give the proportions of all observations made when operators were engaged in defined items of work. Since the observations represent a sample of the total time, proportions of total time are obtained. If, for example, 1 000 observations are made, and, of these, operators are seen to be preset on 300 occasions, then one can say that operators are in the preset position for 0·3 of the total time, i.e. 18 min/h.

Several experienced telephone operators were employed as observers after training in cordless-board operating and observing. The times of observations followed a time-table intended to randomize them with respect to the work being observed. Rounds of observations were made approximately every three minutes, enabling the following results to be based on some 29 000 observations divided amongst the eight traffic loads.

Results

Effect of traffic level. In any paced man-machine system (i.e. the input rate not under the operator's control) with a random input of work, such as for example a telephone



1 *The variation of an operator's preset time, and of her time to answer, with traffic load*

× Time to answer.
○ Preset time with work.
● Preset time without work.

exchange, regardless of the distribution of the service time there will be times when work waits for the operator and times when the operator waits for work.[7,8] Changing the demanded speed of work changes the balance of these waiting times. Fig. 1 shows the effect of traffic load changes on the average time that subscribers waited for their calls to be answered (TTA), and on the average proportion of time that operators were waiting for calls to arrive. This latter relationship is shown in two parts: operators preset without work (lower values) and operators preset with work. The lower set of values of preset proportion represent time during which operators have nothing to do at all. But it is the higher set of values that determine the waiting time of subscribers, since it is during this longer period that operators will answer fresh calls.

The average TTA depends on the number of operators available to answer calls. Other things being equal, the more operators there are, the shorter the TTA. Hence Fig. 1 could not itself be used to predict time to answer at a larger exchange with many more operators. But for any given exchange with its own characteristic traffic loads, the traffic load can be varied only by changing the number of operators. Thus a relationship similar to that shown in Fig. 1 (× × ×) might be expected for a larger exchange. The proportion of preset time, however, depends only on traffic load and operator time per call. The relationship of Fig. 1 (○○○) expressing this is therefore likely to hold for other exchanges regardless of size.

Converting the proportion of preset time in the manner described earlier gives the values of operator time per call shown in Fig. 2. Plotting these against the logarithm of the traffic level results in a close approximation to a straight line, with a marked shortening of the time as traffic level is increased. Increasing the number of calls per operator per hour from 25 to 50 decreases the operator time per call by roughly 30 sec (about 30%).

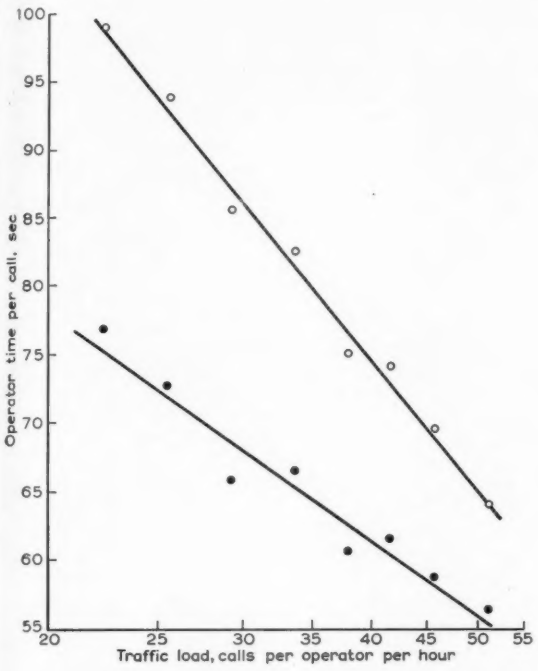
Since the TTA depends partly on operator time per call it is clear that the relationship shown in Fig. 1 between traffic load and TTA differs from any that might be calculated on an assumption of constant operator time. But if the relationship in Fig. 2 can be accepted as of general validity, a basis is provided suitable for modifying current conceptions of average delay in answering calls.

Discussion

When considering the results presented, we have to remember that the measures of human performance made were indirect and are subject to sampling errors. This sampling error is unlikely to be large, because a relatively large sample of work has been examined, and it is even less important in considering trends rather than absolute values. Again with several observers, systematic errors of individual observers may begin to cancel each other and in any case are unlikely to affect the general trends. But measurement was not by clock, and this fact should be borne in mind as a caution.

It might, though, be relevant to note that, some time after the experiment had ended, the normal staffing schedules were redrawn for a trial period of several months. The intention was to maintain the average traffic load per operator at a considerably increased value, to see whether the resulting time to answer under ordinary operating conditions differed substantially from that recorded during the experiment. In fact, for comparable loads, the difference was within approximately 5%.

The experiment, however, was carried out at an atypical exchange, and the general validity of the effects shown may need revision. In this connection one might distinguish between primarily psychological effects, and primarily bio-statistical effects. Operator time per call is an example of the former. The decrease shown with



2 *The variation of operator time per call with traffic load*
○ Operator time including preset work.
● Operator time excluding preset work.

increased traffic must be understood entirely in terms of a free human reaction to environmental changes. The system within which the operator worked may have encouraged her to work faster, but it could not compel her to do so. The proportion of operator waiting time, on the other hand, is a bio-statistical function. It depends partly on how fast the operator works, and partly on how frequently calls arrive. The psychological functions found from this study are likely to hold for other types of exchanges; the bio-statistical functions would need to be carefully examined to determine how far they would be disturbed by changes in the more mechanical features of some other exchange.

The present state of telephone exchange mathematics theoretically enables one to predict the average time to answer and the proportion of operator idle time if operator time per call and traffic level are known. But in attempting to predict the effects of changes of traffic level, some estimate must be made of what the operator time per call will be under the changed conditions. The results of the present experiment show that such an estimate can be quite practicably made.

Fig. 1 adopts the useful concept developed by Brigham[7] of counterposing the delays on either side of the 'store counter'. One can, for example, decide on an acceptable level for average time to answer and read off along the bottom axis the traffic level which would give that value. One can read from the left-hand vertical axis the proportion of operator waiting time that there would be at this traffic level. So long as the relative importance of delays on both sides can be established, the optimum traffic level can be determined. But this will not necessarily be at the intersection point, unless the two vertical axes are scaled in units to represent steps of equivalent importance. This serves to emphasize the need to consider operator performance very early on in the design of exchange equipment. One might easily design a system to give (e.g.) a five-second time to answer, and then find that the traffic level required also leaves operators either with too much or too little idle time.

The effect of the demonstrated dependence of operator time per call on traffic level has a considerable influence on the performance of the system regarded as a whole. Consider a case where 360 calls arrive per hour, handled by 12 operators. For a traffic level of 30 calls per operator per hour, Fig. 2 shows operator time per call to be about 68 sec. One might wish to predict what the average time to answer would be if the number of operators were to be reduced to 9. From published graphs (e.g. those of Wilkinson[8]), if operator time is assumed to be independent of traffic, the predicted time to answer would be about 10 sec, which would probably be unacceptable. If the dependence is recognized and the operator time taken for a traffic level of 40 calls per operator hour, i.e. about 61 sec, then the calculated time to answer would be approximately 4·5 sec. If constant operator time is accepted, predictions of time to answer will be too high, and more operators will tend to be used than would be needed to give the desired service.

The method used has proved to be a useful tool for studying the behaviour of the system as a whole, yielding information about the performance of the equipment and the operators, and in particular about the performance resulting from the interaction of the two. Current queueing theory, when it has been applied to the problem of predicting the output of a system with known input, has of necessity considered only the case where the 'service time' is independent of the input rate. Where 'service' is by human beings it is almost certain that this case will not provide correct solutions. In the present example a psychologically highly complex operation made up of many components has been shown to decrease in time with an increased input rate. One cannot at present predict with certainty for a specified operation what effect input changes will have, but in any case an assumption of independence will be dubious.

Acknowledgments

The experiment would not have been possible without

the continuous help and encouragement of Mrs. M. Swaffield of the Inland Telecommunications Department of the Post Office. Miss C. I. Scott, the Chief Supervisor, Mr. J. Martin, the Exchange Superintendent, and indeed the entire staff of the Thanet exchange must be thanked for their daily assistance. The Union of Post Office Workers, through Miss Nan Whitelaw, co-operated in every way.

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CORRESPONDENCE

VARYING ATTITUDES ON TECHNICAL CHANGE IN HISTORY

From H. W. S. MARSHALL, ASSOCIATE MEMBER*

I am writing apropos of the article by Mr. Landon Goodman in the *Journal* for October 1957. When I was an apprentice I had to rise early in the morning. Too often, especially in the winter, the alarm would ring, I would shut it off, and I would then go through in detail the whole unpleasant business of getting up and getting dressed; but only in my imagination. Then, with a sigh of relief and a clear conscience, I would relapse peacefully back into sleep. But there was, of course, a reckoning afterwards.

It is interesting to observe a parallel in industry to-day. The alarm is the realization that, because of falling profits, increasing competition, shortage of labour, or other similar changes in the general situation, something must be done. The act of imagination is the new directive on policy that is hatched out, that looks quite excellent on paper, and that may even be so. The slipping back to sleep again is the failure to realize that words must be backed by deeds, and that continuous and patient effort is necessary to obtain the practical implementation of a new policy.

The majority of more senior executives, being human and seldom as young as they were, have an inherent devotion to the *status quo* and a built-in resistance to anything that calls for a change in their normal habits—especially a change in their normal habits of thought. On the face of things they may accept a new policy directive, because there is rarely any alternative but to appear to do so at least; but they may not back the new policy, and may often successfully oppose it by passive resistance or deliberate half-measures. Many will even be genuinely unconscious of the fact that this is what they are doing.

The new and ever-changing policies that are necessary to-day in every field covered by management require deliberate and unremitting effort to obtain their timely and effective implementation. But management seems to be permeated at all levels by the belief that nine-tenths of the job is to appreciate a problem, conceive a solution, and prepare a directive; whereas in fact at least nine-tenths of the real job is to get the directive understood, accepted and implemented. Few policy directives will be effectively implemented unless they are genuinely accepted, and few will be so accepted unless they are first fully understood by all concerned.

When management discovers, possibly rather late in the day, that the beautiful new directive on policy does not seem to be producing the expected results, but that all is going on much as before, the natural reaction is to deliver a swift kick downwards. This may certainly achieve results, though these are not likely to be the ones desired when the policy was formulated. One probable result will be a considerable, if temporary, dislocation of the organization concerned, in which the just will suffer with the unjust; in fact the just will probably suffer more, for, being keen on their job, they are less likely to pay attention to the instinct of self-preservation. Another probable result is to inculcate in the organization an abiding dislike and distrust of the new policy that is causing all the upset.

The need to-day for any management actively to educate every person in its organization to accept the necessity for rapid and continuous change seems to be much less appreciated in Britain than in America; but perhaps this is understandable. There never has been a time in America when the rate of change in the general mode of life of the population was not fairly rapid. In Britain, however, there have been long periods in its history when any change in the general mode of life of the majority of the population has been so slow that it seems to have bred acceptance of, and a liking for, the *status quo* as a national characteristic. Unfortunately, whatever the virtues of this characteristic, it is not suited to the industrial conditions prevailing to-day.

* Mr. Marshall is with the Iraq Petroleum Co.

DIMENSIONS IN DISPUTE

From H. G. GANGE, GRADUATE

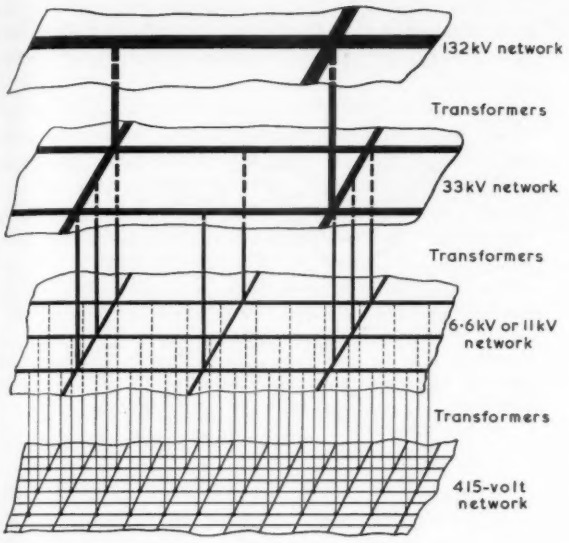
The mathematics of modern science has, I believe, only an operational validity, and its processes are not necessarily concerned with reality. Length, mass and time, however, belong to the real world and are inseparably interwoven in it.

Another 'world' is created by the terms length, mass and time when related in accordance with the whole field of modern mathematics. A certain regularity is discernible in the natural world, but it would appear from the article 'Dimensions in Dispute' in the November *Journal* that this other 'world' is not so consistent.

Manweb Distribution

This article discusses some aspects of electricity distribution in the light of present practice in the area of the Merseyside and North Wales Electricity Board (Manweb). It is founded on the address given in Liverpool on the 1st October 1956 by Mr. Stowell as Chairman of the Mersey and North Wales Centre of The Institution for the year 1956–57. The author is Chief Engineer of the Merseyside and North Wales Electricity Board.

PETER d'EYNCOURT STOWELL,
B.SC.(ENG.), MEMBER



Some History

ONE of the important things that must be emphasized about public electricity distribution networks is that they have evolved over a long time and therefore contain many features of past practice. These features have a bearing on future design, because one has always to make the best use of what one has, and they make it somewhat difficult to be categorical about a distribution network, because it is never a coherent entity exhibiting characteristic features uniformly throughout.

Quite apart from progressive changes in distribution practice as techniques have improved over its 60–70 years' existence, the electricity supply industry has passed through several eras which have had a considerable effect on development. First there was the d.c. era, when each power station served its neighbourhood within a very small radius, strictly limited by the use throughout of the voltage at which the consumers were supplied. Next came alternating current, with generation usually at 6·6 kV. This enabled the distribution distance to be greatly increased, but still it was characteristic for most localities to be supplied by the local power station, and, as the load grew, more and more generating plant was installed there. The third era began with the introduction of the 132 kV Grid under the 1926 Electricity Act. Even this did not alter the basic feature of a distribution system being centred on a single supply point, because, although the Grid did interconnect generating stations, certain provisions of the Act made it uneconomic for most undertakings to take a supply at more than one point.

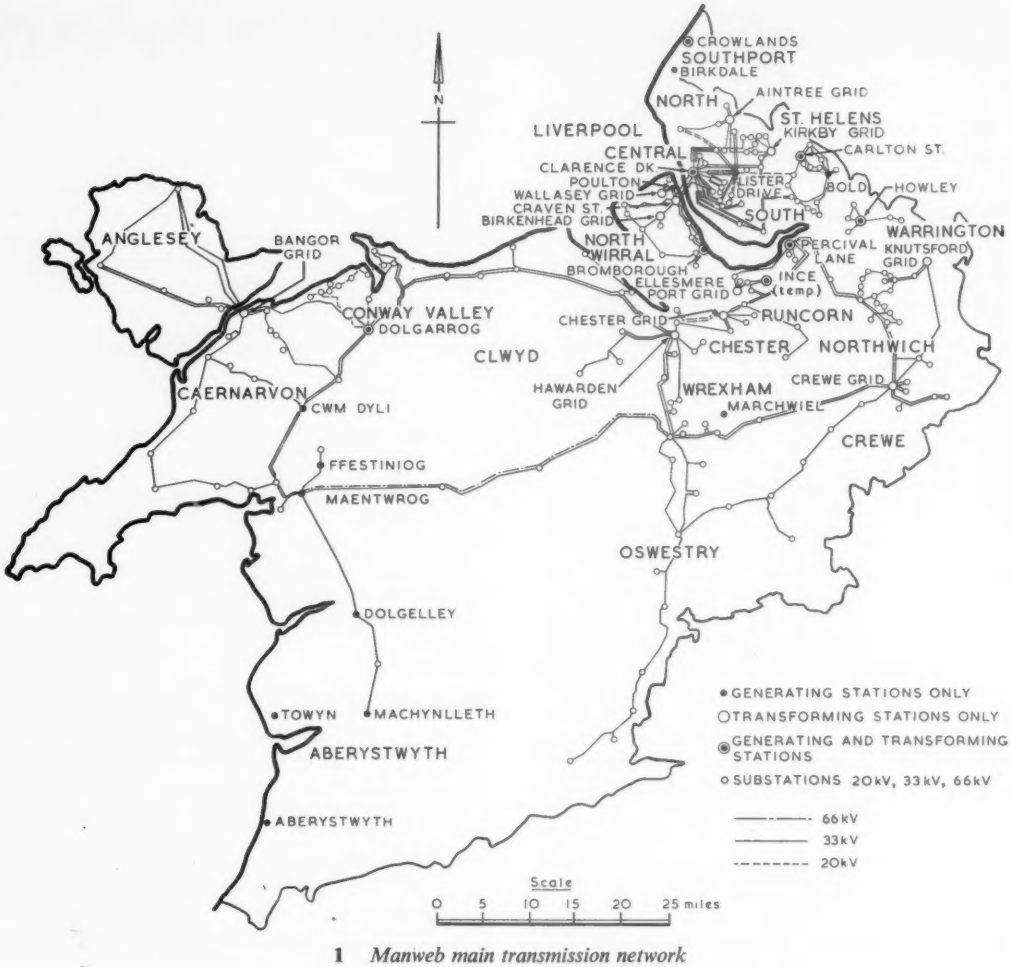
So we see that from the beginning distribution systems continued to be developed each around a single point of supply. This method of development had the inevitable result that many distribution centres became much too large for the voltage in use.

The fourth era, that of complete integration, is the one we are now in. It started in 1948, as a result of the 1947 Electricity Act. The Act made it possible to depart from the idea of distribution networks emanating from a single point of supply, and to adopt an integrated method of distribution which would make full use of a system of networks at different voltages, fed in succession one from another.

Distribution Networks in the Manweb Area

At the time the Merseyside and North Wales Electricity Board came into being in 1948 (Fig. 1, p. 16), the distribution system taken over consisted of sections operating at practically every voltage used in Britain, from 110 volts up to 132 kV. The networks that were most common were those at 240/415 volts, 6·6 kV, 11 kV, 33 kV and, of course, the 132 kV network.

Although the nominal 240/415-volt distribution network is the one that has perhaps the least notice taken of it, any distribution system invariably has a considerably greater mileage of mains at this voltage level than at all the other voltages put together. Manweb now has 7700 miles of 240/415-volt mains out of a total of 14000 miles of mains; and it is in the 240/415-volt networks that about half the Board's invested expenditure lies. Moreover, this expenditure consists not only of the cost of the cables—I refer to the urban underground systems—but of the cost of burying them in the ground, and this is at least as expensive as the cables themselves. It follows that it is seldom economical to lay down small mains in the first place and to add additional copper later as the load grows, because of the cost of digging up the ground twice. At the same time one obviously cannot afford at the outset to put down a network of mains and substations which would cater for all future needs, even if one knew for certain what the future had in store. However, the load with which a network can deal can be increased enormously without increasing the size of the mains, by increasing the number of feeding points, so increasing the number of paths over which the power can be distributed and, at the same



1 *Manweb main transmission network*

time, reducing the distance over which it has to be distributed (Fig. 2). It is, of course, well known that voltage drop is one of the most important limits to the capacity of a distribution network, particularly at the lower voltages, and that if the distribution distance is halved the power that can be distributed is doubled.

Therefore, it is sound practice to aim at a network of 240/415-volt mains, which, once provided, will not be expected to require material additions at any future time, and, of course, it is desirable economically to use the minimum size of cables that will serve this purpose. The network is fed by transforming stations, and the distance to be distributed, and hence the capacity of the network, are determined by the spacing between the substations. So, at the beginning, when the demands on the network are relatively small, a limited number of substations are provided, others being added progressively as the load grows.

To make this arrangement work out in practice, the mains should be of reasonably uniform size throughout; otherwise it is impossible to add a new substation without expensive additions to the 240/415-volt mains to connect it into the network. Unfortunately, in some of the networks put down in the past, the principle was adopted of using a large variety of sizes of mains to suit the expected load on them. Thus very large mains were used near the initial substations, where the current was high, tapering to small mains on the fringes between substations, where it was low. As a consequence there was a tendency to enlarge the size of substations without increasing their number, instead of increasing the number and retaining a uniform size of substation; in particular, transformer sizes tended to grow larger.

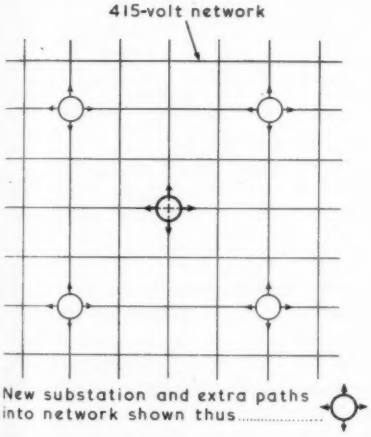
Large transformers for 240/415-volt distribution, say of 1 000 kVA and above, are undesirable, because the loss of any one of them due to breakdown is a serious embarrassment. With large transformers, and particularly with a tapered network, it is usually quite impossible to transfer the load to neighbouring substations. The consequence is that each substation has to be self-

supporting, and duplicate transformers in each substation become the rule rather than the exception. This, obviously, means a poor utilization factor and adds considerably to the cost. If, on the other hand, transformer sizes are limited and the network is not tapered, the load of any one transformer can be redistributed among its neighbours, and high utilization factors are possible. This is the principle of what I call the network system, which I wholeheartedly believe to be the best arrangement; it applies not only to the 415-volt network, but also to the higher-voltage networks.

The largest transformers now used by Manweb to feed 240/415-volt networks are rated at 500 kVA, and the network itself is composed mostly of $0{\cdot}1\,in^2$ cables reasonably uniformly throughout—except for spurs, for which smaller sizes are satisfactory, and for the very short connections into the substations, where $0{\cdot}2\,in^2$ cables are occasionally necessary.

Larger Loads

The foregoing is especially appropriate to those networks where the load of each consumer does not deviate too widely from the average value. Potentially, at least, this is true of networks serving suburban residential areas. But, of course, many networks exist in which, in the course of time, the character of the load

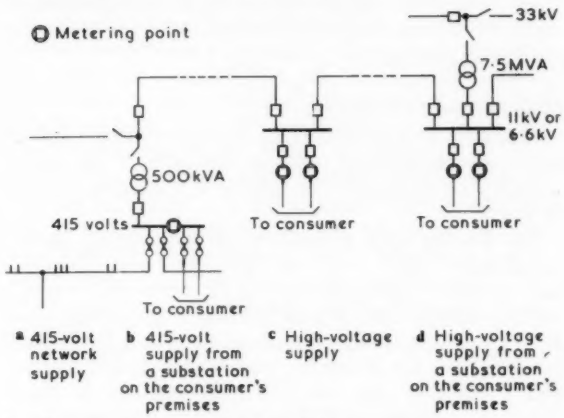


2 *Increase in capacity of a network by adding a new feed point*

alters owing to change in the use of premises, and here and there individual loads much greater than the average appear. Both here, then, and in industrial and urban areas, one has the problem of how to deal with these larger loads, for there is obviously a limit to the size of an individual load which can be tapped off the 415-volt network (Fig. 3*a*) without running into serious trouble. The solution in general is that the larger individual loads must be carried on the high-voltage network direct. For really large loads the consumer is supplied at high voltage, i.e. 6·6 kV or 11 kV (Fig. 3*c*), at which voltage the supply is metered, and the consumer himself transforms to meet his requirements. As a *quid pro quo*, such consumers have always been offered a reduced tariff, which takes into account the reduced cost of supplying them.

To give a supply at high voltage, however, entails considerable costs in switchgear and metering equipment, and this is substantially independent of the size of the supply. So there is a lower limit to the load for which a high-voltage supply is economic.

And, by whatever scale one adopts, a considerable gap exists between the load which can be supplied economically from the 415-volt network and that which



3 *Some typical methods of supplying consumers*

can be supplied economically at high voltage. Although the upper limit for supply from the 415-volt network has usually been recognized, the lower limit of supply from the high-voltage network often escaped notice, and apparently still does in some areas. This lower limit occurs at about 500 kVA, both for economic reasons and because it is virtually impossible to design a satisfactory current transformer of sufficiently small size for a primary current less than 40 amp. This represents about 500 kVA at 6·6 kV, or 800 kVA at 11 kV.

Of course, one way of getting round (rather than over) this difficulty is to give the supply on paper at high voltage, but to meter it at the 415-volt terminals of the transformers, and to use some calculated adjustment for transformer losses. This method has been used, but it is somewhat roundabout and has little influence on the economics of the case.

Every endeavour is made by Manweb to work to a limit for supplies direct from the 415-volt network in the region of a demand of 60 kW, or 100 kW of installed load. For higher demands, supplies are still given at 415 volts but not direct from the network; the supply is through a transformer (Fig. 3*b*) which the Board provides on the consumer's premises, and there is a separate tariff for this type of supply. As the high costs associated with the 415-volt network are not incurred, the tariff can be much more attractive than for supplies direct from

the 415-volt network. The consumer has to provide on his premises space and housing for the high-voltage equipment and transformer, but no more than he would for a high-voltage supply, and he has the advantage that he does not become the owner of high-voltage equipment which he may not have the staff to operate, nor has he to worry about the breakdown of this equipment. The standby supply is provided by Manweb from neighbouring transformers over the 415-volt network, and this arrangement also enables economic use to be made of any transformer capacity which, at any time, the consumer does not require. So it is possible to offer a tariff for 415-volt supplies from a transformer, which up to 500 kVA is normally more attractive to the consumer than any other tariff.

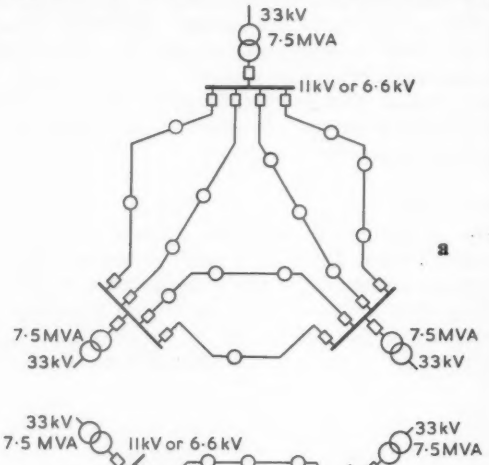
High-Voltage Distribution

Apart from some 250 miles of high-voltage mains at half a dozen different voltages below 6 kV, the high-voltage distribution in the Area is at a nominal 6·6 kV or 11 kV.

On Vesting Day practically all the densely loaded urban areas used 6·6 kV, and the greater part of the less heavily loaded rural areas used 11 kV. Some undertakings were modifying their 6·6 kV networks to operate them at 11 kV; others were quite satisfied with 6·6 kV. Such modifications are expensive, particularly in urban areas, and I consider that the increased capacity is better obtained by spending money on the development of a 33 kV network. But in the Manweb Area the boundaries between the 6·6 kV and 11 kV networks have been a considerable handicap to proper development of a high-voltage network. So the length of these boundaries is being reduced as far as possible by eliminating the 6·6 kV network from rural areas, and from all the smaller urban areas where it exists surrounded by 11 kV lines. The larger areas of 6·6 kV network will remain, but the boundaries are being retracted somewhat to the most satisfactory position that can be found. Nevertheless, apart from transformers, all the equipment which is being used on these networks is suitable for operation at 11 kV.

At one time almost all the generating plant fed direct into the 6·6 kV and 11 kV networks. The present position is vastly different, and the generators connected to 6·6 kV and 11 kV networks now represent only 15% of the total capacity. Generators connected to the 33 kV network and the 132 kV network at present make up the remainder of the total about equally. Generation at 6·6 kV or 11 kV led inevitably to high values of short-circuit power. Even when generation ceased at a point in the network it was natural to substitute an equivalent capacity of transformers, because sufficient copper was installed to distribute a large supply from the point. So short-circuit levels of about 500 MVA at 6·6 kV and 11 kV are still in existence in some places.

Many people seem to think of short-circuit levels as being concerned only with switchgear. The attitude is rather that if a proposal results in a particular short-circuit level at a predetermined voltage, all that has to be considered is whether switchgear of that rating is obtainable and whether the scheme can bear the cost of it. I believe this attitude to be something of a snare and delusion. Almost all components of distribution systems are, sooner or later, affected by fault conditions, and they have to sustain these conditions for the short time during which a fault remains on the system. This may be two seconds, and cables which carry more than 50 kA/in² for this time cannot be guaranteed not to have been permanently damaged throughout their length. So, on this hypothesis alone, it follows that even if the network contains no conductors of less than 0·3 in² the fault current should not exceed 15 kA, no matter what switchgear can be designed to do.



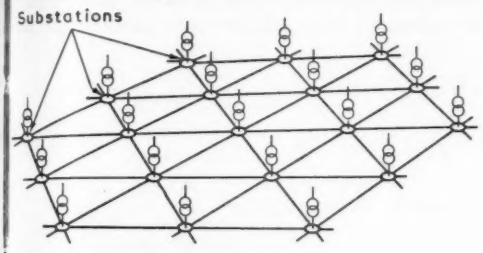
4 *Preferred grouping of transformers in the Manweb Area*
a Three transformers. b Two transformers.
The arrangements are equally applicable to 132/33kV transformers.

A fault current of 13·1 kA has been adopted by Manweb as the maximum permissible both with 6·6 kV networks, for which it represents a short-circuit level of 150 MVA, and with 33 kV networks, for which it represents 750 MVA. At 11 kV, 150 MVA is also normally used as the short-circuit level, because the 11 kV networks happen to be less densely loaded than the 6·6 kV ones; there is thus no general need to make use of the higher short-circuit level of 250 MVA, which corresponds to 13·1 kA at 11 kV.

Transformer Arrangements

To keep short-circuit levels down to the stated figures is not easy. It entails, in particular, avoiding the concentration of too much transforming capacity at any one place. This is a good thing to do, in my opinion, for other reasons similar to those I have already given in discussing large substations for feeding a 240/415-volt network from a high-voltage one.

There exists, however, the contrary opinion which favours large substations because of the difficulty in obtaining substation sites. But, if the largest transformers are used, it is possible to keep the short-circuit level low only by arranging that each transformer feeds a separate section of network, and full duplication is then invariably necessary. Such an arrangement has the disadvantage that it is virtually impossible to contrive that the circuits



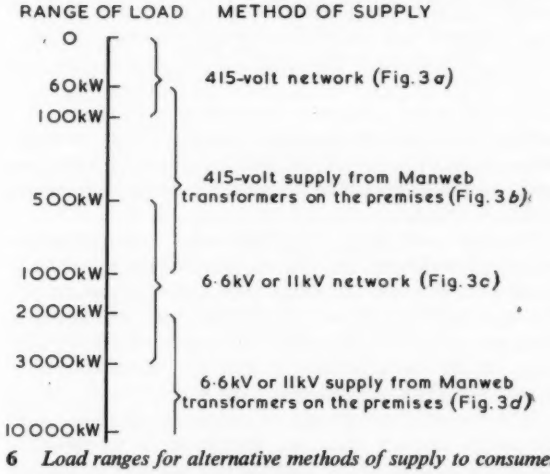
5 *Distributed in-feeds to a network*

have alternative means of supply, so that each fault causes an interruption of supply, and restoration has to be effected by switching. On the other hand, if two or three transformers operate in parallel, it can be arranged that supplies will not be interrupted at all on the occurrence of a fault. This is a decided advantage and forms the basis of Manweb policy. Then again, there is a choice between installing several transformers at one point—at least one acting as spare for the others, and doing no more than that—and installing each transformer at a different point. The second method has the merit that the distances over which the power has to be distributed at the lower voltage are considerably less, with less voltage drop and lower distribution losses. So Manweb policy is based on using groups of two or three transformers, each one at a separate substation where possible (Fig. 4). The impedance of the network between them permits an aggregate capacity of 22·5 MVA (i.e. three 7·5 MVA transformers in parallel) without exceeding a short-circuit level of 150 MVA at 6·6 kV or 11 kV.

In my opinion, the ability to parallel three transformers is a very advantageous arrangement. It is desirable to be able to add transformers to the network one at a time, and, to maintain full continuity of supply, two at least must be paralleled. A little consideration shows that the ability to parallel three is necessary to avoid one having to be the odd man out. The arrangement of transformers in pairs—a popular arrangement, but undeservedly so, I think—means that under normal conditions transformer loadings should not exceed half of their capabilities. With three transformers the corresponding figure is two-thirds, which is 33% better. This applies when three transformers are located together. When they are dispersed singly, on a network, the conditions can be even better, because each transformer (Fig. 5) is then geometrically surrounded by about six others, and, if the size is not excessive compared with the transfer capacity of the network, there will be sufficient spare capacity even if each transformer is normally loaded up to six-sevenths of its capability. This would be 70% better than for paired transformers.

The Economic Load Limit for High-Voltage Supply

Just as there is an economic limit (100 kW) to the size of individual load which can be tapped off the 415-volt network, so is there an economic limit to the size of individual load which can be tapped off a 6·6 kV or 11 kV network. The limit is obviously related to voltage, and 1 500 kW at 6·6 kV corresponds in round figures to 100 kW at 415 volts on a pure voltage basis. Actually other factors affect the problem, and it is usually economic for an individual consumer's load up to 3 000 kW to be tapped off a 6·6 kV network. The limit of 100 kW at 415 volts is fairly widely acknowledged, but the 3 000 kW limit for a 6·6 kV network does not seem to be so generally recognized. Again, supplies given and metered at 33 kV, leaving the consumer to transform to his utilization voltage, are not economic for loads below about 10 000 kW. Therefore, Manweb practice for a load above 3 000 kW is for the Board to provide a transforming station on the consumer's premises (Fig. 6). The consumer provides the site and building and takes



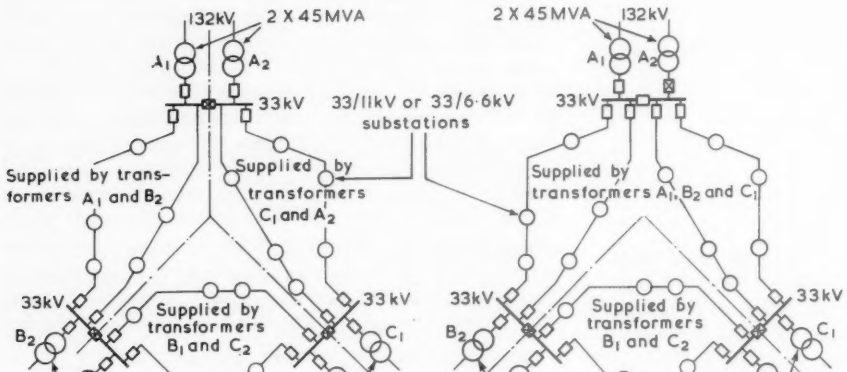
6 *Load ranges for alternative methods of supply to consumers*

over the supply at 6·6 kV or 11 kV according to the network voltage near his works (Fig. 3*d*); that network is used to provide the consumer's supply in emergency and to absorb surplus transforming capacity. For supplies from 33 kV substations on a consumer's premises, special terms are available, so that here again the consumer is given the benefit of the advantages which accrue from his load not normally involving network costs.

Feeding the 33 kV Network

The supplies to the 33 kV network now come direct from the 132 kV Grid and are the subject of arrangement with the former Central Electricity Authority. The

conditions are basically no different, however, from those obtaining at lower voltages. The points of supply to the 33 kV network must again be limited in capacity, or there result short-circuit levels higher than 750 MVA, which are undesirable. In this Area the preferred size of Grid transformer is 45 MVA. It permits three such units to be run in parallel within the 750 MVA limit at 33 kV (Fig. 4*a*). There are at present in the Area a number of points of supply having a single 45 MVA transformer. Two or three such transformers will be run in parallel



7 *Operation of Grid points in parallel through a 33-kV network*

a All transformers in service.
b One transformer out of service.

▭ Circuit-breaker closed.
⊠ Circuit-breaker open.

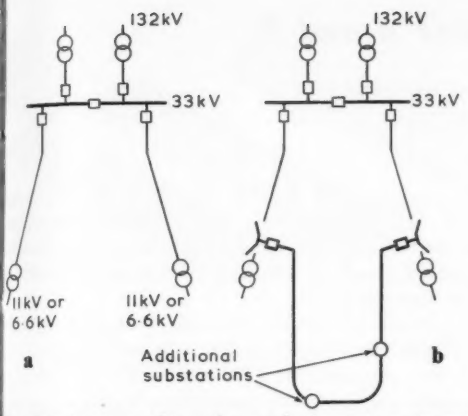
so that no transformer is merely a standby for another, and each is effective all the time to assist in reducing losses, and in maintaining a uniform voltage throughout the 33 kV network.

The more orthodox two-transformer arrangement is also being continued, but investigations have shown that the custom whereby the two transformers are normally run in parallel, with a split in the network between adjoining supply points, can be improved upon. The defect in this arrangement is that the necessary splits prevent the 33 kV circuits being fed at both ends, which is desirable in the interests of supply continuity. It is normal to connect the two transformers to separate sections of busbar, and the alternative method makes use of this arrangement by normally running with the bus-section circuit-breaker open to separate the pair of transformers, and having each of a pair of transformers paralleled through the network with a corresponding transformer at a neighbouring supply point (Fig. 7*a*). The 33 kV circuits are then fed at both ends of each from independent points of supply. When one transformer is out of service, it is still possible to maintain the double-ended feeds by closing the bus-section circuit-breaker at the supply point affected (Fig. 7*b*). With 45 MVA transformers, this is permissible within the 750 MVA limit for the short-circuit level, and the arrangement allows each pair of supply points to be loaded to the capability of three, instead of two, out of the four transformers.

Switchgear and Protective Gear

One of the facets of electricity distribution engineering on which opinion differs most is switchgear. The reason for this varied opinion undoubtedly lies in the fact that switchgear in general is the least useful feature of a distribution network. Everyone accepts that cables and overhead lines perform the necessary function of distributing the electricity from place to place, and that transformers perform the useful function of changing from one voltage to another, but switchgear—using the term broadly—although it is comparatively expensive fulfils only two rather negative functions; first, it removes faults from a network which would be better if it had no faults, and, secondly, it enables maintenance to be carried out on other network components which would be better if they needed no maintenance. Nowadays much time is properly spent in trying to eliminate switchgear—the passenger on the network—as far as possible.

Protective gear is part and parcel of switchgear. In a desire for economy it is possible to take the attitude that, for instance, if a circuit-breaker cannot be eliminated altogether, it can at least be made less expensive by reducing the protective gear associated with it. Indeed there is evidence that in some places, although circuit-breakers have been accepted as a necessary evil, proper protective gear has been regarded as an even worse evil. This, in my view, is the wrong approach to the matter altogether. It is something like having a body without a brain. I believe that the proper outlook is almost the reverse. It works on the lines, first, of providing without question the protective gear which is essential to detect the faults that inevitably will go on occurring on the network; and secondly, of providing the minimum number of circuit-breakers—the expensive components—to remove the detected faults from the network. This entails deciding the largest amount of network that it is permissible to disconnect for each fault. Put in other words, a circuit-breaker should be regarded as a final



Development of transformer feeders into a ring main
a Stage 1. b Stage 2.

relay in a protective system—the device, in fact, that merely opens the main circuit when the protective equipment decides that it should be opened.

One of the early applications of the 'full-protection minimum-number-of-circuit-breakers' technique was the so-called three-switch 132 kV substation with two lines and two transformers, in which three circuit-breakers are made to do all the duties for which another technique would require five. In some Areas very extensive use is made of transformer feeders as a means of eliminating switchgear. However, the tie of equality which this entails between the ratings of feeder and transformer is a handicap, because the economic conditions governing the optimum size of the two are materially different. This arrangement also appears to have the disadvantage that a real network does not result. The wholesale use of transformer-feeders leads, in fact, to each supply point being surrounded by circuits emerging from it radially, and it would appear inevitable that future development will tend in the direction of increasing the capacity of existing supply points, instead of increasing their number. That, in turn, could lead back to a situation which was characteristic of a past era, namely excessive concentrations of power and excessive short-circuit levels.

In the Manweb Area, transformers are connected direct to feeders only in special instances, and their sizes are not equalized because they are used simply as a stage in development of a network and not as a permanent feature (Fig. 8*a*). Economy in switchgear is, however, achieved by means of ring-main units. These could be regarded merely as a means of making extensible feeders connected direct to transformers, but they are in fact used as a complete arrangement of rings (Fig. 8*b*). This practice has been followed elsewhere, but to a much more limited extent than is deserved by the flexibility coupled with economy which it provides.

The Future

What has the future in store? Perhaps the most remarkable thing about the electricity supply industry is the way in which the load has doubled itself over and over again, in periods of time which have been as short as seven years and seldom longer than ten years. Every now and then there have been indications of a lessening of this rate of increase, but they have invariably turned out to be no more than temporary variations from the mean rate. It seems difficult to expect it to continue indefinitely, for saturation must eventually occur. But, in my opinion, saturation is still a long way off. The rate of load doubling every ten years could imply a doubling of the network every ten years, and the resulting necessity of building in the next ten years as much as has been built over *all* the years to date. But in practice, the lower-voltage networks remain substantially unchanged and are made to carry an ever greater load by introducing injection points at ever decreasing distances. Most of the development that takes place, therefore, is the development of the higher-voltage networks. The 132 kV Grid was once regarded as a pure transmission network and it was, for instance, quite an event in the country as a whole when an additional transforming station was put into service. Now it is necessary in the Manweb Area alone to commission two or three new 132 kV stations every year, and ten years from now twice as many will probably be needed annually. The 132 kV Grid must, therefore, come to be regarded much more as a distribution network than anything else, and the same fate will no doubt in due course overtake the 275 kV Supergrid as well.

It is difficult at this time to foresee anything that could vastly affect the course of progress in electricity distribution. Nuclear energy may do so eventually, but at present that energy seems unlikely to be distributed other than in the form of electricity. So I conclude with the thought that distribution networks will continue to grow, and that the growth will in general follow established practice; but existing methods and materials will continue to be progressively improved, especially perhaps in the field of insulation. Those people who are engaged in the distribution of electricity can rest assured that the future holds much in store to keep them interested, for many problems have yet to be solved. There will be no shortage of work to be done, from which they will be able to derive pleasure and pride in rendering an ever more important service to the community.

COVER CHANGES

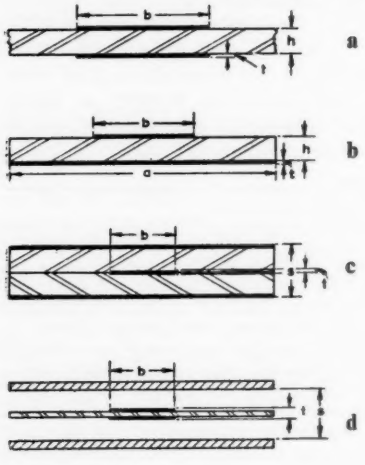
Even members who open their *Journals* hurriedly will not have escaped the sensation that something is different in the cover this month. The elements of the previous design are still there; but The Institution's title has slipped back 90° in phase, to the relief no doubt of that band of critics who have always objected to reading from south to north instead of from west to east. Whether the colour is now a true electrical blue or a university one is problematical, but if the latter, those who support 'another place' and feel that The Institution's East Anglian interests have been given over-tangible expression should remember that the Dark Blues had their innings on the *Journal* cover two years ago. It is hoped too that members will approve of the new use for the back cover, which last year was left blank to reduce the cost of ink used in printing the solid colour.

SHORT REVIEWS OF PAPERS

Microwave Printed Circuits

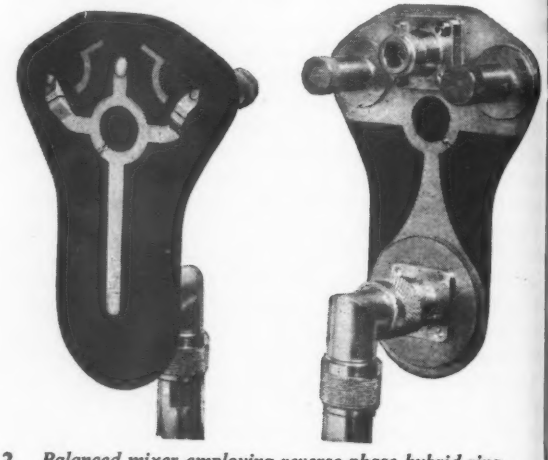
A short review of three Radio and Telecommunication Section papers (Nos. 2401, 2402 and 2444) entitled 'The Application of Printed-Circuit Techniques to the Design of Microwave Components', 'Broad-Band Slot-Coupled Microstrip Directional Couplers' and 'Re-entrant Transmission Line Filter using Printed Conductors', by J. M. C. Dukes, M.A., Associate Member. Papers 2401 and 2402 were published individually in August 1957; paper 2444 was published individually in November 1957. The papers will be republished in Part B of the Proceedings. The author is with Standard Telecommunication Laboratories.

DURING RECENT YEARS CONSIDERABLE EFFORT HAS BEEN devoted to reducing the cost, bulk and weight of microwave circuits, a trend which has been accentuated by a continual increase in complexity of the circuits. Indeed, some of the circuits proposed would hardly be practicable in the absence of any drastic improvement in these respects. The problem has been attacked in a number of ways, most of which rely on improved manufacturing techniques, e.g. casting, electroforming, automatic tooling, etc., and the adoption of light-weight alloys. A further improvement can be obtained if the complete circuit is manufactured in the form of a single block instead of an assembly of isolated components. A more radical approach, however, has led to the consideration of several less conventional transmission systems as an alternative to hollow waveguides. Of these, perhaps the most promising is the strip transmission line, several varieties of which are shown in Fig. 1. The cross-section can generally be made smaller, the materials are inherently lighter, and the geometry is such as to facilitate fabrication by printed-circuit techniques.



1 *The four practical types of strip transmission line*
a Balanced line. b Microstrip. c Triplate. d High-Q triplate.

As the result of experience, the so-called *photo-mechanical* method of printing has been adopted as the one that best provides the high standard of definition and accuracy required. A laminated board of some high-grade material such as p.t.f.e.-impregnated glass fibre is generally employed. The board is supplied clad with copper foil (0·001 4 inch thick), which is removed where not required by chemical etching, the foil to be

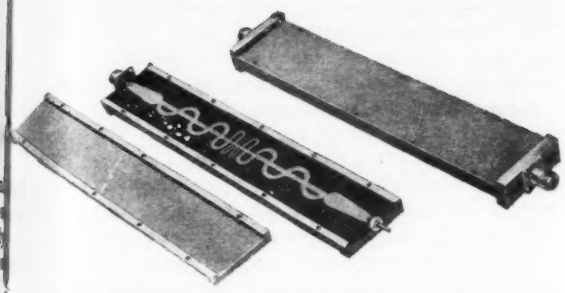


2 *Balanced mixer employing reverse-phase hybrid ring*

retained being protected by a photographically deposited resist.* By the use of this technique it is possible to print complicated circuits involving, for example, a complex array of graded slots, with a dimensional stability of the order of a small fraction of 0·001 inch. This is at least one order of magnitude better than the tolerances on the thickness and electrical properties of the glass fibre board. With the exception, perhaps, of the arrangement shown in Fig. 1*d*, where the dielectric is in the weak-field region, it is the variation in the properties of the laminate which provide the principal limitation on electrical reproducibility.

The technique of designing components in strip transmission-line form does not differ radically from that employed with conventional waveguide systems. It is essential, of course, to possess the necessary data relating

* A *resist* is a chemically neutral substance which resists the action of the electrolyte.

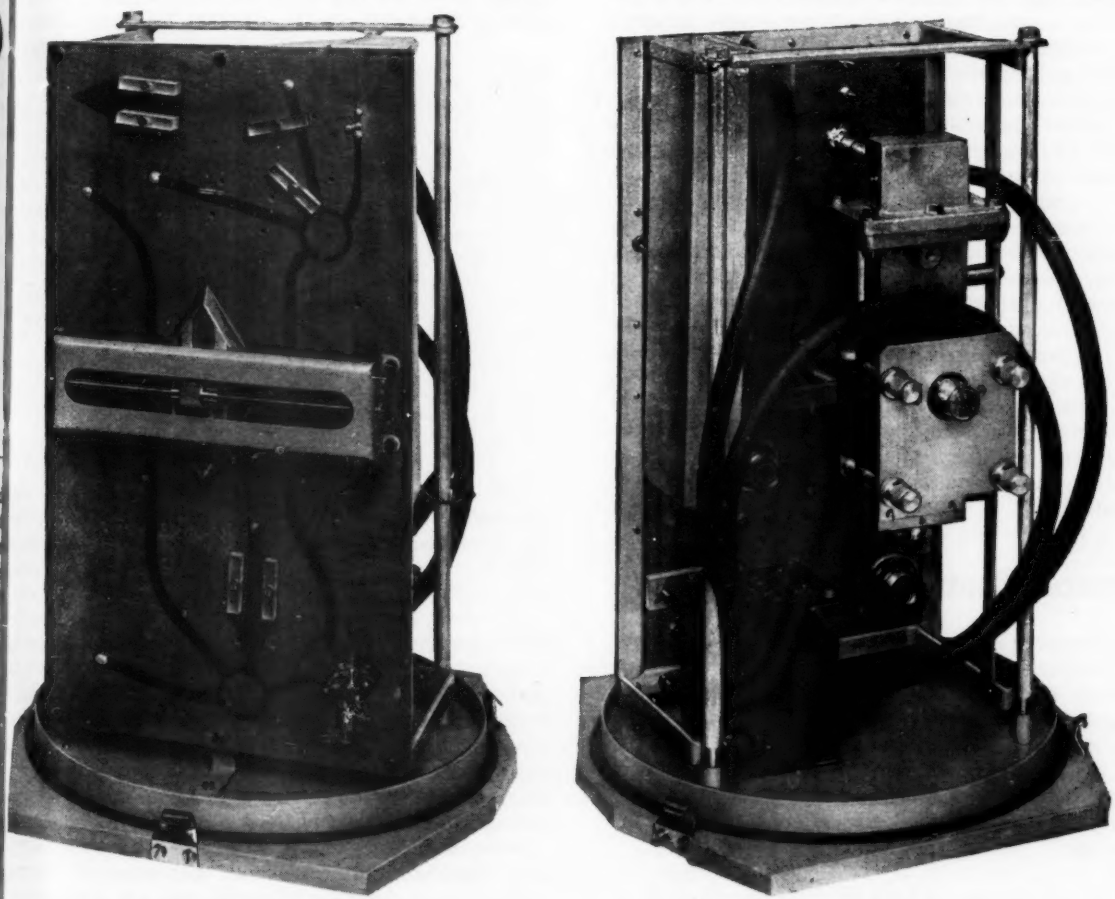


Tapered re-entrant-line low-pass filter

The filter is composed of a cascade of filter sections, the curved line effectively re-entering the straight line.

o characteristic impedance, phase velocity and attenuation. However, under certain circumstances, difficulties ay be experienced owing to propagation in a spurious ode or even radiation. For this reason the use of the rst two lines of Fig. 1, which are somewhat more prone o such effects, has generally been confined to low-Q-actor broad-band components. Since strip transmission lines, like coaxial cables, are virtually non-dispersive, it is often possible to achieve bandwidths unattainable with conventional waveguides. More recently, however, improvements in the technique have led to the development of filters having a performance comparable with that of good waveguide filters. The principal limitation, which is unlikely to be overcome, is the inability to handle the high power levels encountered with radar systems.

Several examples of the technique are illustrated in Figs. 2, 3 and 4. The first is a balanced mixer complete with hybrid ring, crystal holders, series matching capacities, and r.f. output filters. The hybrid ring, which is partly in balanced line (Fig. 1*a*), and partly in line above ground (Fig. 1*b*), is of the so-called *reverse-phase* type. The phase reversal, which consists of an abrupt interchange of the upper and lower conductors, presents a surprisingly small discontinuity effect with virtually negligible radiation. The usable bandwidth of the hybrid ring is 2 500–4 200 Mc/s, over which range the decoupling averages 25 dB, with a minimum value of 19 dB. Over the same range the equality of power split is better than 1 dB. A 3 dB coupler having a similar performance has



Microstrip duplex working r.f. head

also been developed. In this design two microstrip lines are mounted back to back, and the coupling is achieved by means of a series of transverse slots printed in the common ground plane. Since the cost of fabrication is determined to a very minor extent only by the complexity of the circuit, the slot pattern may be elaborated to almost any degree in order to obtain the desired coupling and directivity functions. Fig. 3 shows a novel type of low-pass filter, this time in high-Q-factor triplate line. The passband insertion loss is generally less than 1·5 dB, except in the immediate vicinity of the cut-off frequency. In the range 4 050–4 200 Mc/s the attenuation rises by 40 dB, and from 4 200 to 12 000 Mc/s the insertion loss is in excess of 30 dB. In a specimen batch of four of these filters, the pass-band insertion loss varied by less than 0·5 dB. The final example, Fig. 4, shows a complete duplex-working r.f. head involving the integration of a number of microstrip components. The circuit, in effect, forms a filter separating the transmitted and received signals, which differ in frequency by 60 Mc/s. Only one oscillator is employed, which serves the common function of transmitter and local oscillator for the receiving circuits.

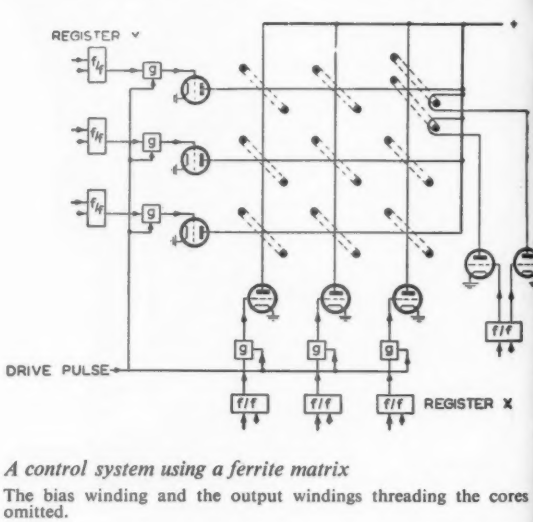
To summarize, there is no doubt that strip-transmission-line circuits can show important advantages in cost, weight and bulk, but at the expense, perhaps, of a slight degradation in performance and some restriction of application owing to the limited power-handling capacity. There is also some doubt regarding the ability of materials such as p.t.f.e.-impregnated glass fibre to withstand conditions of extreme humidity, though this should not prove a limitation if the equipment is hermetically sealed. Perhaps the biggest handicap to any extensive application at present is lack of knowledge and experience. Compared with conventional waveguide technology, the information available to the circuit designer is comparatively slender and sometimes contradictory. In addition, the measurements are inclined to be more involved, and the technique of mathematical analysis more intricate. In due course these limitations will presumably be overcome, and there is little doubt that the strip-transmission-line technique will then find fairly extensive employment in the appropriate fields of application. 621.372.821.049.75: 621.372.832.43: 621.372.542.2

Computer Control Unit

A short review of a Measurement and Control Section paper (No. 2365) entitled 'The Design of the Control Unit of an Electronic Digital Computer', by M. V. Wilkes, M.A., Ph.D., F.R.S., Associate Member, W. Renwick, M.A., B.Sc., Associate Member, and D. J. Wheeler, Ph.D. The paper was published individually in June 1957, and it will be republished in Part B of the Proceedings. The authors are at the Mathematical Laboratory, University of Cambridge.

WHEN A CALCULATION IS PREPARED FOR SOLUTION ON AN automatic digital computer, it is split up into a series of simple operations, each of which is specified by an orde The operations themselves are each split up into sequence of steps, and each step is carried out by t application of a pulse to a set of circuits or gates. It the function of the control unit of a computer to produ the sequences of pulses for this purpose. The object the work described was to develop a control unit f Edsac 2, a parallel binary computer, which would simple in structure, and which would be applicab whatever the exact form of the final order code.

Initially, diode matrices were proposed for generati the sequences of pulses, and any change in the order co entailed repositioning the diodes in the matrices. Dio matrices are suitable for automatic computers wi relatively simple order codes, but become uneconomic if the order code is comprehensive and includes orders f floating-point operation. However, the production rectangular-loop ferrite cores makes possible the develo ment of a system using a matrix of cores with coincide current selection. Each core corresponds to a particul step in the execution of one order. When a core switched in the matrix, it must activate the gates require for the corresponding step, and also cause the co defining the next step to be selected. Two sets of wir



A control system using a ferrite matrix

The bias winding and the output windings threading the cores omitted.

thread the cores in the matrix. Each wire in the first gro is connected to one of the gates in the machine, and, the other group, the wires are connected to the flip-flo in the X and Y registers controlling the matrix. The wires are threaded through the cores according to t order code required; any change in the order co necessitates rethreading some of the cores. The system shown in the much simplified schematic.

Some of the steps are *conditional* on the state of so other flip-flops in the machine. For example, duri multiplication the steps taken depend on whether t multiplier digit is 0 or 1. These conditional steps a

ovided by locating two cores, each with an extra bias inding, at an intersection. One such intersection is own in the schematic. In Edsac 2 it is possible to nse two external digits simultaneously, by locating four res, each with two extra windings, at an intersection.

Experiments have shown that matrices of at least $\times$ 32 cores can be constructed and operated at a equency of 700 kc/s. While such a 32 $\times$ 32 control atrix, providing a comprehensive order code, was eing constructed, Edsac 2 was operated with an experiental 8 $\times$ 6 matrix. This was in operation for over a ear and proved very satisfactory in performance.

621.374.32 : 518

dder with Stored Addition

short review of a Measurement and Control Section aper (No. 2389) entitled 'A Decimal Aader using a Stored ddition Table', by M. A. Maclean, M.Sc., and D. spinall, B.Sc. The paper was published individually in ly 1957, and it will be republished in Part B of the roceedings. The authors are at the University of Manchester.

NE OF THE PROBLEMS ENCOUNTERED BY THE DESIGNER OF ecimal computing machines is the awkwardness of andling decimal numbers with computing elements and orage devices which are, by their nature, best suited to binary representation. The various ways of repreenting decimal numbers with binary elements are ompromises between economy and logical complexity. general the least complicated methods involve the ost equipment and vice versa.

An adder using a stored addition table has the most traightforward logic. In its simplest form, however, it equires that 100 separate sums be stored. This figure an be reduced if the decimal digits are coded in biuinary form but at the cost of introducing a base-five arry, which reduces the speed of the adder.

A more economical method is to code each decimal igit into the form of a four-digit binary number. If, owever, two such digits are now added according to the sual rules for binary addition, the process is complicated by the fact that the radix of the decimal system is ot an integral power of two. Furthermore, the speed of he adder must be low enough to allow time for the ropagation of the three binary carries.

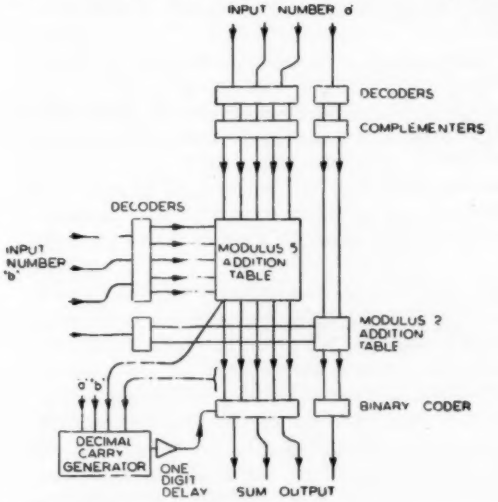
The addition-table type of adder is attractive because its simplicity and its greater speed. By using a special rm of number representation, it has been possible to onstruct it more economically without losing these dvantages. The method, which bears some resemblance bi-quinary coding, is to replace each decimal digit by pair of digits. The first of these can have any value etween 0 and 5 and is the remainder obtained on viding the decimal digit by five. The second can be or 1 and is the remainder on dividing by two. Fig. 1 shows the results for the ten decimal digits. The expression 'residue modulo five (or two)' means 'the remainder when the number concerned is divided by five or two'.

Decimal digit	Residue modulo five	Residue modulo two
0	0	0
1	1	1
2	2	0
3	3	1
4	4	0
5	0	1
6	1	0
7	2	1
8	3	0
9	4	1

1 *Residue representation of decimal digits*

To add two digits represented in this way, the two residues modulo five are added, and from the sum a new residue modulo five is found. This requires the storage of twenty-five possible sums. The same is done with the residues modulo two, requiring the storage of four sums. The two resultant residues then correspond to the desired decimal sum if this is less than ten, or to its least significant digit if it is greater than ten. The two additions involved are carried out independently by separate circuits, and no carry is required between the two channels. This is the chief advantage of the residue system compared with bi-quinary coding, and the same economy is obtained, only twenty-nine sums having to be stored instead of 100. The decimal carry, which is calculated separately, is added to the sum in the following digit period by increasing by unity the outputs of both the modulus five and the modulus two channels.

For the sake of economical storage, numbers enter and leave the adder coded in four-digit binary form. The first three digits represent the residue modulo five and



2 *Block diagram of decimal adder*

the fourth the residue modulo two. Fig. 2 is a block diagram of the adder, including the coding and decoding circuits as well as arrangements for complementing one of the input numbers when subtraction is desired.

The adder was built with circuit elements which use junction transistors and square-loop magnetic cores. The cores, which are of the type used for digital storage, are made to act as logical discriminators by biasing them to saturation in one direction wtih a steady current. The paper discusses the design of the circuit elements and the effects of component parameters upon their performance.

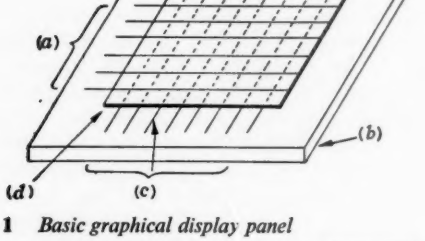
About eighty transistors were used altogether, including some used for storage at the input and output of the adder during testing and some used for waveform generation. The digit repetition frequency, limited by the transistors, was 50 kc/s. 621.374.32

Electroluminescent Graphs

A short review of a Measurement and Control Section paper (No. 2441) entitled 'An Accurate Electroluminescent Graphical-Output Unit for a Digital Computer', by T. Kilburn, M.A., Ph.D., D.Sc., Member, G. R. Hoffman, Ph.D., B.Sc., and R. E. Hayes, M.Sc., Student. The paper was published individually in October 1957, and it will be republished in Part B of the Proceedings. The authors are at the University of Manchester.

A LARGE NUMBER OF RESULTS OBTAINED BY USERS OF THE Manchester University Mark 1 computer have been laboriously plotted by hand in graphical form. This has shown the need for a stable graphical plotting unit with an accuracy at least as good as that given by normal graph paper. In the device described in the paper the graphical output is given by producing a series of spots on a special electroluminescent panel* and photographing these spots to give a permanent record of a continuous trace.

The construction of the graphical panel is shown in Fig. 1. The two electrodes, one on either side of a thin uniform layer of plastic-embedded phosphor, are divided into a set of parallel conducting strips. These strips are at right angles with a separate connection to each individual strip. The conductors form a co-ordinate matrix, and the selection of one conductor from each side defines a spot position at their intersection.

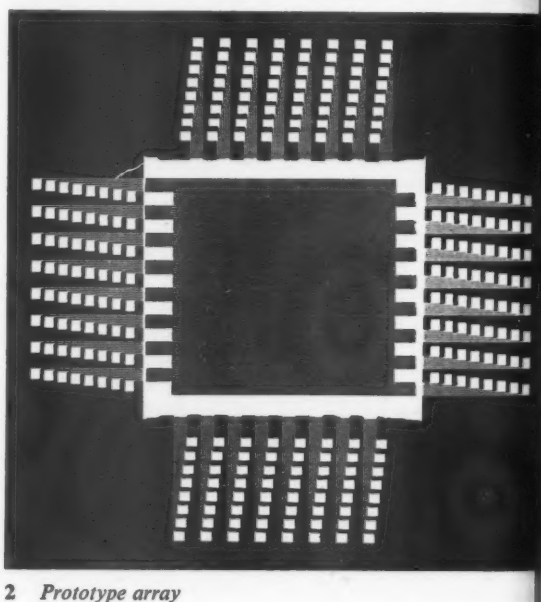


1 *Basic graphical display panel*

a Opaque conductors.
b Glass.
c Transparent conductors.
d Phosphor in plastic.

A simple method of operating the panel is to apply anti-phase voltages of $V/2$ to the selected strips with the others earthed, so that a voltage V appears at the wanted intersection, producing a bright spot. Owing to the voltage $V/2$, the whole of each selected strip also luminesces, but with a lower intensity. The ratio of wanted to unwanted brightness levels is called the *discrimination ratio*. By biasing all the unselected strips of a co-ordinate set with an anti-phase voltage of one third that of the selected strip, the unwanted intersections are now subject to an amplitude of $V/3$ volts. Under typical operating conditions the improvement in discrimination ratio is from 600 for a system using voltages V and $V/2$ to 80 000 for a system using voltages V and $V/3$.

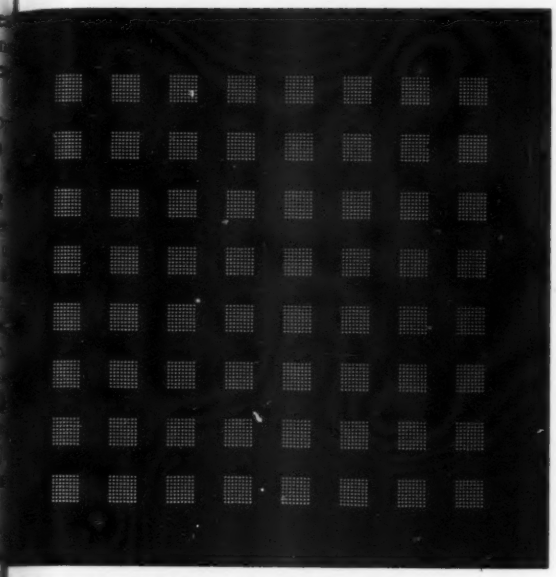
The graphical output unit now in production has 512×512 orthogonal conductors spaced at eighty to the inch, defining over a quarter of a million spot positions. A prototype 128×128 matrix with conductors at fifty to the inch is more easily reproduced here (Fig. 2), the outer area of the glass supporting panel being used to accommodate a 'flag' pattern to allow separate electrical connection to the conductors. As an example of the resolution of the prototype, eight groups of eight conductors on both axes have been selected simultaneously and the luminescent pattern photographed, giving sixty-four spots at each major intersection (Fig. 3).



2 *Prototype array*
Half actual size.

Photo-etching techniques are used in the manufacture of the panels, and a spot position is thus determined

* See *Journal*, August 1957, p. 454.



Symmetrically illuminated prototype array
Actual size.

he master negative, which has been fabricated to fine imits. The electroluminescent graphical output unit has herefore a built-in accuracy with an inherent stability, nd it is hoped that it will be a useful addition to the ecently installed Mark II computer at Manchester University.

621.317.7.087.6 : 621.374.32 : 681.142

Thermal Endurance

A short review of a Graduate and Student Section paper entitled 'The Thermal Endurance of Insulating Materials', by J. A. Denham, B.Sc.(Eng.), Graduate. The paper was read before the North-Eastern Graduate and Student Section on the 18th January 1957, and it was awarded a Graduate and Student Premium by the Council. The author is with C. A. Parsons and Co.

THE EFFECT OF OPERATING TEMPERATURES UPON INSULATING materials has been a problem of increasing importance and was a source of concern even before E. H. Rayner first investigated the problem at the National Physical Laboratory in 1905. A recent development has been the publication by the British Standards Institution of B.S. 2757 : 1956—a classification of insulating materials on the basis of thermal stability in service.

There are several important consequences of a rise in temperature of insulating materials in service. The material will expand, and because of differential expansion between insulation and conductor, stresses and subsequent abrasion may be caused. There may be changes in electrical properties, especially in dielectric loss factor (tan δ), and also in mechanical properties, but a most important result of temperature rise is an increase in the rate of chemical deterioration. Most dielectric materials fall into the chemical class of organic compounds, and almost without exception are liable to undergo slight changes in chemical constitution owing to the presence of oxygen, moisture, chemically active materials and ionized air.

The most common form of chemical deterioration is slow oxidation, which, by introducing acid groups into the polymeric or liquid insulation, increases the conductivity and loss factor of the insulation. Oxidation also splits up the polymer chains in plastic insulation and decreases the tensile strength. An important consequence of deterioration is brittle hardening caused by loss of plasticizer, and, in plastic insulation, by the excessive oxygen cross-linking of polymer chains. Plasticizers are added to plastic insulation to increase its flexibility, but tend to evaporate slowly at high temperature, thereby increasing the hardness of the material and also introducing shrinkage. Another type of deterioration is the thermal depolymerization of plastic insulation, whereby polymer chains break into shorter units. This reaction tends to be slower than oxidation but occurs in all polymers, including cellulose, at elevated temperatures even in the absence of oxygen, and it is an important factor at high temperatures.

The thermal endurance of an insulating material depends largely on the rate of chemical deterioration and can be defined as a measure of the ability of that material to retain good electrical and mechanical properties for a reasonable working life under service conditions, particularly the service temperature. It also generally implies the ability to withstand higher-than-normal temperatures for short periods without any serious effects upon its insulating properties. Thermal endurance is usually stated as a life of a number of hours or years at a certain temperature, with any necessary qualifications included.

It is clearly necessary to evaluate this very important property for all insulating materials incorporated in electrical equipment, and for new developments such as irradiated polythene. Service experience is the most reliable way of assessing the value of a material, but neither the designers nor the manufacturers of any new material can wait for such experience, which may take many years to accumulate. Therefore some method must be devised whereby a rapid estimate can be made in the laboratory of the thermal properties of a new insulating material.

The problem of predicting the useful life of an insulating material under certain operating conditions is one of the most difficult confronting the electrical engineer. The time taken by the examination is clearly important and must be reasonably short. The most convenient way of predicting working life is to undertake a number of high-temperature tests for a short period. For example, if a new material intended for Class B operation is to be examined, tests at 200–250° C will be expected to last for some six months. The criterion by which the material is

judged is either a comparison made with a standard or a certain condition attained during ageing, such as the reduction of tensile strength to 50% of its initial value. A graph of temperature against the time to reach a criterion is plotted, and, if the law governing the relation between temperature and time is clearly understood, extrapolation of the graph will give an indication of working life at the lower temperatures under the test conditions.

The laws governing chemical ageing do not lend themselves to simple extrapolation. They are complex functions of temperature, time and the working conditions (relative humidity, presence of oxygen, etc.). Even so, general laws have been evolved which have proved reasonably efficient in practice. One of these is the 'ten-degree rule', which states that the thermal life of insulation is halved for each 10° C increase in temperature, or doubled for each 10° C decrease. This rule is not universally applicable, but it is useful for cellulose-based materials and has been shown to be useful with plastics.

T. W. Dakin has evolved a method of prediction giving a linear relationship between time and temperature, therefore making extrapolation easier and more dependable. He assumes that the observed physical changes are the result of internal chemical reactions which obey well-established theoretical laws.

It is essential when examining new materials that sufficient duplication of tests is carried out to obtain a good average result. Variation in results due to slight differences in the production of test samples and any variations occurring in the method of measurement should be noted.

Accelerated ageing tests are useful provided test conditions approximate to service conditions, but they are generally somewhat makeshift. They serve one important function in eliminating poor materials. 621.315.61

Diesel-Electric Design

A short review of a Graduate and Student Section paper entitled 'Project Considerations for Diesel-Electric Traction', by R. S. Wignall, B.Sc., Graduate. The paper was read before the North Midland Graduate and Student Section at Bradford on the 5th March 1957, and it was awarded a Graduate and Student Premium by the Council. The author is with the English Electric Co.

THE RAILWAYS OF THE WORLD COVER 803000 MILES AND are located in 113 countries with widely varying climatic conditions. To satisfy such conditions, a manufacturer of Diesel-powered locomotives may use two basic approaches. Either a standard unit of proved design is built by mass-production methods, or selected components are tailored to meet the requirements of individual customers. The former alternative is hampered by six common track gauges and by a variation of loading gauge with nearly every railway system.

The customer specifies either the power required fr... the unit, or information in the form of train weights a... time-tables from which it may be deduced. The specifi... power may be required at altitudes of up to 15000 ft, ... in ambient temperatures of up to 115° F, with or witho... 100% humidity, while at the same time the power u... must be kept within a reasonable weight. These extre... climatic conditions may be accompanied by tra... flooding, a prevailing wind, sea-water, dust or seve... snow. Occasional local hazards are encountered; f... example, vegetation scattered on the track in fores... areas has recently affected the performance of cert... locomotives, although this was not known at the desi... stage. Thus, the Diesel engineer is faced with seve... problems.

From engines of the greatest power/weight ra... within the manufacturer's range, it is necessary to sel... a suitable power unit which can be built into mechani... parts to comply with the customer's maximum axle loa... In some instances, a larger number of small units w... help to solve this problem.

The customer must assist in providing informati... such as time-tables, graphical or tabular, and the loa... to be hauled over various sections. An accurate prof... showing the location of all curves and gradients ... essential.

Where a proposed locomotive has to operate on t... prevailing gradient for long periods, it is essential th... the electrical machines are rated to function continuous... without overheating (in common with any machi... application).

Power Units

For a given range of engines, there are known mi... mum weights to which a locomotive can be built for ... given maximum axle load. These depend on the weig... of the maker's power unit, and it behoves the engi... designer to produce a high power/weight ratio in ord... to use the minimum necessary number of axles.

Typical axle loads for locomotives built with hea... and light power units are shown in the table.

Axle loads for engines of different power/weight ratio

Number of axles	Specific weight of power un...	
	13·5 lb/h.p.	20·3 lb/h.p.
	tons	tons
4	27·5	30·0
6	18·3	20·0
8	14·0	15·0

In practice, it is normal to provide an individual dri... to each axle, but this is not always possible whe... maximum axle loads are very low. In such cases it m... be necessary to construct composite wheel arrangemen... for locomotives powered by 12- and 16-cylinder engin...

The maximum tractive effort that can be exerted ... starting is limited by the adhesion between wheel an...

uired fro… rail. With individually driven axles, the wheel will eights a… transmit a force of approximately 25% of its own weight e specifi… on the rail.

5000 ft, … The main generator winding is matched to the or witho… available crankshaft output of the engine, usually ower u… making use of the nearest size in a series of standard e extre… frames. Great latitude in the design of winding will assist by tra… in economizing in copper on main generators, when or seve… working with heavily derated engines.

tered; f… The number and type of traction motors must be n forest… decided, and at the first attempt it is usual to match the of certa… continuous current rating of the motors with that of the he desi… main generator.

th seve… The heat to be dissipated from the Diesel engine to the …il and water radiators must be assessed and a suitably ght ra… …ized radiator designed. Individual investigation for each to sele… project is necessary, since the same combination of echanic… climatic conditions, engine rating, and available space is axle loa… rarely repeated. It is essential that the engines should be units w… derated to allow for site climatic conditions, and this …alculation is done at the project stage.

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Auxiliaries

The provision of air or vacuum brakes, or both, calls for power to drive exhausters and compressors, and other auxiliaries such as traction-motor cooling fans, lights, batteries, cab heaters and perhaps ventilators.

Where a radiator fan is electrically driven it is normal to supply the power from the main generator, thus varying the fan speed according to the air quantity required.

In conjunction with an estimate of auxiliary load, it is necessary to assess at an early stage the weight of the entire electrical and mechanical equipment; these estimates can be made with surprising accuracy, based on previous experience.

Performance Calculation

Once the machine designers have decided on the degree of weak-field needed to achieve the tractive effort required at high speed, and the number of stages necessary to avoid overloading the main generator, they will produce an output characteristic of the generator/motor combination. This will provide the raw data for the projects engineer, from which he can determine the performance expected from the equipment.

The resistance to motion of any vehicle is made up of three variable factors, all of which can be readily calculated from the geometry and weights of the particular vehicle. The general form of the resistance is a quadratic function of the speed. The resistance of passenger trains varies little between the empty and the loaded condition, since the passenger load is relatively small.

The resistance equation and the output characteristic are combined to provide in graphical form the tractive effort available at the wheel tread throughout the speed range.

In order to predict the performance of proposed equipment under particular conditions, the customer is asked to provide a set of speed limits and an accurate profile. On severe curves the speed must be restricted.

With this information available, the projects engineer is in a position to produce a speed/time or speed/distance curve. The longest and most tedious method is to perform a routine calculation of successive integration on a slide rule, determining the time and distance covered by a finite speed increment. A more modern method is to use an Amsler train-schedule computer, which carries out the same operation by means of ball-type mechanical integrators and plots the solution on a speed/distance chart. By far the most rapid means of calculation is by an electronic computer such as Deuce, which can be programmed to print the results in tabular or graphical form.

To establish that the electrical machines are not overheated in meeting the schedule, the total value of $\int I^2 dt$ must be calculated. On the Amsler and Deuce computers this is done as a part of the normal computation. An estimate of the fuel consumption is also made.

When a project involves the application of new equipment, the layout and the method of driving the auxiliaries must be examined to ensure a symmetrical distribution of weight on the locomotive axles.

In mountainous country, there is often justification for dynamic electric braking, enabling higher speeds to be maintained without wear on brake shoes. Characteristics for the equipment must be drawn out at the projects stage and used in the performance calculations.

621.335.2–833.6

SYNOPSES OF PAPERS

Effect of Fading on Ionospheric Measurements

A synopsis of a Radio and Telecommunication Section paper (No. 2428) entitled 'The Effect of Fading on the Accuracy of Measurement of Ionospheric Absorption', by R. W. Meadows, B.Sc.(Eng.), Associate Member, and A. J. G. Moorat. The paper is published this month in Part B of the Proceedings. The authors are at the Radio Research Station.

THE RAPID AND SLOW COMPONENTS OF A FADING SIGNAL are separated by a semi-empirical process in which each component is, in turn, assumed to consist of a steady or specularly reflected component with a random component added. The process is applied to some measurements of the amplitude of first-order reflections from the

E-region at vertical and oblique incidence on equivalent frequencies. The standard deviation of the amplitude variation due to rapid fading was found to be greater at vertical than at oblique incidence, but insufficient evidence is yet available to determine whether the variation due to slow fading was also greater.

The accuracy of measurement of the smoothed value of field strength is defined as the range of values having a 99% chance of containing the correct value. On this basis, the accuracy of noon absorption, as calculated from a single day's observations at one frequency, has been estimated to be about +4, −12 dB at vertical incidence and +4, −11 dB at oblique incidence. These limits are not symmetrically disposed about the mean value, as is conventional in normal statistics, partly because of the effect of the decibel scale, and partly owing to the characteristics of deep fading. 621.396.11

Earth's Field and Radio Propagation

A synopsis of a Radio and Telecommunication Section paper (No. 2429) entitled 'The Effect of the Earth's Magnetic Field on Absorption for a Single-Hop Ionospheric Path', by R. W. Meadows, B.Sc.(Eng.), Associate Member, and A. J. G. Moorat. The paper is published this month in Part B of the Proceedings. The authors are at the Radio Research Station.

MAGNETO-IONIC CALCULATIONS SHOW THAT DEVIATIVE absorption is not necessarily negligible at vertical incidence for waves reflected from the E-region at frequencies considerably below the penetration value. Consequently, the value of absorption calculated by the conventional 'non-deviative' formula for a short-wave oblique path from vertical-incidence absorption measurements tends to be too high. Deviative absorption on paths sufficiently oblique is, however, negligible. The calculations also show the effect of the earth's magnetic field on Martyn's absorption theorem to be similar to the effect of losses due to partial reflections: namely to make the absorption in decibels, calculated from an oblique path from vertical-incidence measurements, too low by a multiplying factor approaching the cosine of the angle of incidence. It is suggested that the absorption to be expected on a radio path might best be calculated by applying the conventional non-deviative formula to measurements made at oblique rather than at vertical incidence. 621.396.11

Hall-Effect Wattmeter at 10 Gc/s

A synopsis of a Radio and Telecommunication Section paper (No. 2450) entitled 'The Hall Effect and its Application to Power Measurement at 10 Gc/s', by Professor H. E. M. Barlow, Ph.D., B.Sc.(Eng.), Member, and S. Kataoka. The paper is published this month in Part B of the Proceedings. Professor Barlow is at University College, London, and Mr. Kataoka, who was formerly that College, is now at the University of Tokyo, Japan.

THE PAPER DESCRIBES EXPERIMENTS ON THE MEASUREME of microwave power at 10 Gc/s employing the Hall effe produced in single crystals of *n*- and *p*-type germani when erected on the axis of a hollow metal rectangu waveguide carrying the power. So far as is known, t is the first recorded observation of the Hall effect at t frequency, and it has been shown possible to apply t effect, with the help of a suitable phase-adjustment devi to the design of a wattmeter. For this purpose the H output from a crystal was calibrated against the pow measured independently, and the relationship was fou to be practically linear.

From these power measurements and consideration the conditions of operation of the crystal, the H coefficients for the *n*- and *p*-types of germanium us were deduced and shown to be of the same order magnitude as the d.c. values.

An investigation of the impedance of the crystal circu led to the conclusion that the contribution to the H effect from the displacement current in the crystal w very small compared with that of the conduction curre

The success of this application depends largely upo the development of suitable crystal units, and towar that end new techniques were introduced. 621.317.38.029

Precision Thermo-Wattmeter

A synopsis of a Measurement and Control Section pap (No. 2461) entitled 'A Precision Thermo-Electric Wa meter for Power and Audio Frequencies', by J. J. Hi B.Sc., Associate Member. The paper is published th month in Part B of the Proceedings. The author is at t National Physical Laboratory.

THE OUTPUT E.M.F. GIVEN BY A CONVENTIONAL THERMA convertor is not proportional to the square of the heat current, and wattmeters using two such converto cannot therefore be used for the precise measurement power. The causes of non-compliance with a square la are examined, and a means of compensation is given t provide a convertor system in which the output e.m.f. within 0·1% of the calculated square-law value.

A wattmeter has been constructed in which negativ feedback amplifiers are used to supply the currents t two compensated convertors. The input signal voltag to the amplifiers are obtained from the external circu by means of a precision wide-frequency-band voltag transformer, a 4-terminal non-inductive current shu and a high-resistance voltage divider.

The insertion loss in the main current circuit is 0·1 vo at rated current, and the voltage-divider resistance either 1000 or 5000 ohms per volt. The overall instru ment error for all conditions of load and power factor 0·1% over the frequency range 200 c/s to 10 kc/s, an 0·3% for the range 50 c/s to 30 kc/s. 621.317.7

Fourier Dispersion Curves for Waveguides

A synopsis of a Radio and Telecommunication Section paper (No. 2468) entitled 'A Note on the Fourier Series Representation of the Dispersion Curves for Circular Iris-Loaded Waveguides', by P. N. Robson, B.A., Associate Member. The paper is published this month in Part B of the Proceedings. The author was formerly with the Metropolitan-Vickers Electrical Co., and is now at the University of Sheffield.

THE DISPERSION CURVE FOR THE LOWEST PASS BAND IN A uniform corrugated circular waveguide, such as is used in travelling-wave linear accelerators, may be expressed as a Fourier series of period $2\pi/$(corrugation pitch). Under the slowest conditions of convergence in the waveguides investigated, an accuracy of ± 1 part in 5000 in the determination of frequency corresponding to a given phase velocity can be obtained by using only six terms of this series. For the majority of structures considered, three terms only are required. An empirical expression for the dispersion curve can thus be obtained from only a small number of experimental results, and is of considerable use in the design of suitable slow-wave structures for accelerators. The equation of the dispersion curve can be readily differentiated to give the group velocity at all points within the pass band.

The validity of the method is illustrated using a selection of experimental results which have been obtained in the course of an extensive programme of measurements on corrugated slow-wave structures for linear accelerators operating at wavelengths around 10 cm. 621.372.823

Reflection of Microwaves

A synopsis of a Radio and Telecommunication Section paper (No. 2480) entitled 'The Use of Dielectric Materials to Enhance the Reflectivity of a Surface at Microwave Frequencies', by G. B. Walker, M.A., Ph.D., and J. T. Hyman, B.Sc.(Eng.), Graduate. The paper is published this month in Part B of the Proceedings. Dr. Walker is at Queen Mary College, University of London, and Mr. Hyman, who was formerly at that College, is now at the Atomic Energy Research Establishment, Harwell.

THE PADDING OF A METAL SURFACE BY ONE OR MORE layers of a dielectric material is examined, and it is shown that an improvement in reflectivity can be obtained provided that the loss factor ($\tan\delta$) of the dielectric is small enough. For most materials the gain is approximately proportional to $\sqrt{\epsilon}/\tan\delta$, where ϵ is the dielectric constant.

Since the reflectivity of a metal diminishes as the frequency is increased, it is to be expected that dielectric padding will become more advantageous at the higher frequencies which can now be generated. For known materials, no improvement is to be expected at frequencies much below 3000 Mc/s, but at that frequency a gain of two was observed for a ceramic material consisting mainly of titanium dioxide.

By laminating a dielectric it is possible to reduce the effective loss factor. A reduction in ϵ must occur, but an overall increase in $\sqrt{\epsilon}/\tan\delta$ can be obtained. In the case of titania, laminating can give a further improvement by a factor of three, and hence at 3000 Mc/s it is theoretically possible to produce a surface which is six times as reflective as a metal. At higher frequencies even greater gains may be possible. 621.37 : 621.372.8 : 621.315.61

Transverse Film Bolometers

A synopsis of a Radio and Telecommunication Section paper (No. 2488) entitled 'Transverse Film Bolometers for the Measurement of Power in Rectangular Waveguides', by J. A. Lane, M.Sc., Associate Member. The paper is published this month in Part B of the Proceedings. The author is at the Radio Research Station.

THE PAPER DESCRIBES A SIMPLE STANDARD TECHNIQUE, using thin metallic films sputtered on mica, for the direct measurement of powers in the range 1–100 mW. The experiments were carried out at a frequency of 10 Gc/s (wavelength 3 cm), but the methods used are of general application in rectangular waveguides.

The absorbing films consisted of a platinum deposit, of the order of 10^{-6} cm thick, on a mica strip 0·3–0·4 cm wide, located symmetrically in the transverse plane. The change in resistance or rise in temperature can be used as a measure of input power, which is determined by a d.c. calibration. The operating bandwidth, for a given waveguide, is greater than that normally available with thermistors and bolometers, and the techniques described seem especially convenient for the calibration of these instruments. 621.317.794 : 621.372.822

Improved Chorded Windings for Induction Motors

A synopsis of a Utilization Section paper (No. 2443) entitled 'Two Improved Chorded Windings for 3 : 1 Pole-Changing', by Professor G. H. Rawcliffe, M.A., D.Sc., Member, and N. L. Garlick, Associate Member. The paper will be published in Part A of the Proceedings. The authors are at the University of Bristol.

THE PAPER DESCRIBES TWO FURTHER AND IMPROVED 3 : 1 pole-changing windings which both have only nine control leads, and in which a 60° spread has been used, instead of the 120° spread which was used in a machine previously described. A particular feature of these windings is that the coil pitch is critical, and can have only one value. Full-pitched coils cause very bad crawling effects. 621.313.333.045.58

MONOGRAPHS AND PAPERS
published individually this month

MONOGRAPHS

Conditions for the Impedance and Admittance Matrices of *n*-Ports without Ideal Transformers *Monograph* 276 R

I. CEDERBAUM

The matrices relating two adequate systems of simple network co-ordinates of the same network, e.g. node-pair voltages or loop currents, are shown to have all their elements and subdeterminants equal to $+1$, -1 or 0. Any n-port may be looked upon as a part of an adequate system of independent node pairs described on the network or loops inscribed into the network. In the former case the additional node pairs, not included in the n-port, ought to be considered as open-circuited and in the latter case the additional loops ought to be looked on as short-circuited. The conditions for cut-set- and loop-incidence matrices are discussed, and then the conditions for impedance and admittance matrices of n-ports without ideal transformers in terms of those incidence matrices are defined. The discussion of the conditions thus derived leads, among other things, to a conclusion that matrices representing pure-resistance n-ports are necessarily such that each principal minor of such a matrix is greater than the modulus of any minor built from the same rows (or columns).

Excitation of Surface Waves *Monograph* 277 R

B. FRIEDMAN *and* W. ELWYN WILLIAMS

The author shows how to locate a dipole source above a dielectric surface so as either to produce as pure a surface wave as possible or to maximize the amount of energy carried by the surface wave.

Network Synthesis on the Insertion Loss Basis *Monograph* 278 R

J. ZDUNEK, DIPL.ING.

The author provides a unified and concise exposition of the general insertion-loss filter theory: methods of synthesis of most important network functions are derived in terms of the prescribed steady-state network performance; also realization procedures are explained and expressed in terms of explicit formulae for direct application to the design of conventional ladder structures with arbitrary numbers of branches.

Two particular networks are solved in detail, namely the symmetrical and the inverse-impedance low-pass networks, and these are unified in a single mathematical treatment. Such unification enables one to consider both of them as one instance of a low-pass analogue ladder structure.

Special emphasis is given to the Cauer–Darlington method of synthesis of networks, whose insertion-loss response approximates in Chebȳshev's sense to the idealized filter requirements; however, Taylor's approximation (maximally flat response) and the constant-k filters are also included.

With the maximally flat and the Chebȳshev pass-band approximations, important explicit formulae for the ladder components are derived for a network with an arbitrary number of branches and an arbitrary termination ratio. These components (ladder coefficients) are thus directly computable from the required discrimination characteristics or the reflection-factor ratio and from the bandwidth specifications.

The Effect of the Ground Constants, and of an Earth System, the Performance of a Vertical Medium-Wave Aerial *Monograph* 279 R

G. D. MONTEATH, B.SC.

The compensation theorem is used to determine the effect finite ground conductivity, and of an earth system, on t performance of a vertical earthed aerial, such as is used f medium-frequency broadcasting. The characteristics affect are the input impedance, the ground-wave field strength f a given aerial current and the vertical radiation pattern. T first two of these together determine the efficiency, which the most important consideration in the design of ear systems. When the effective height of the aerial exceeds 0·1 little can be gained by the use of an earth system exceedi $0{\cdot}2\lambda$ in radius when the ground is highly conducting and 0· or $0{\cdot}4\lambda$ when it is poorly conducting. The effect of the ear system on the vertical radiation pattern is shown to unimportant practically, but results are given for one case order to compare with experimental radiation patterns. T agreement is quite good.

A Rapid Method of Analysing the M.M.F. Wave of a Single Polyphase Winding *Monograph* 280 S

R. F. BURBIDGE, B.SC.

The usual method of evaluating the harmonic components the m.m.f. wave of a polyphase winding is to perform Fourier analysis. This can, however, be a long and tedio process, especially for stepped waveforms.

The method described here is exceptionally simple to appl and makes use of the well-known standard winding factor It is shown that, by simple substitution, the magnitudes the Fourier fundamental and harmonic components of t m.m.f. in the air-gap can be found directly, although indication is given of their relative phase angles. The math matics of the proof has been fitted as closely as possible the conditions prevailing in a real machine winding, whilst the same time maintaining generality of treatment.

The value of the method is exemplified in the last section the paper, by carrying out the analysis for an m.m.f. wave some complexity. The ease of the method is at once apparen

Diffraction by Cylindrical Reflectors *Monograph* 281 R

R. PLONSEY

The electromagnetic diffraction problem is formulated terms of the determination of the currents induced on reflector-scatterer by a primary source. All field quantities a readily determined therefrom.

An approximate solution ignores the interaction of curren on the reflector-scatterer in that it relates the surface curre to the incident magnetic field. This is the geometrical-optic current. For the strip and circular reflector with line source its centre, corrections to the geometrical-optics currents a obtained by an approximate analytic technique. In each ca this yields an equivalent line current at the edges.

The field of the line current is non-isotropic; its direction gain is determined by appealing to the Sommerfeld half-plan solution. The line currents do not greatly affect the tot pattern; this indicates that the main character of the diffractio can be obtained from the geometrical-optics currents.

The Inherent Instability of Induction Motors under Conditions of Double Supply *Monograph* 282 U

PROFESSOR J. C. PRESCOTT, D.ENG., *and* B. P. RAJU, M.SC.

A polyphase induction motor provided with balanced windings on both stator and rotor can operate as a synchronous motor at a certain specified speed if each of these windings is connected to a balanced polyphase supply. Under the conditions of such double supply it can maintain this specified speed over a range of mechanical power output, thus exhibiting a synchronizing torque similar to that associated with the conventional synchronous machine.

In addition to this synchronizing torque, there are present also torques which, being proportional to the speed of rotation, may be regarded as damping torques and which under certain circumstances may be negative, i.e. they may act in such a direction that a deviation from synchronous speed, though initially very small, will increase exponentially, thus making synchronous operation impossible. It is to the investigation of these damping torques that the discussion in this paper is directed, and they are considered in relation to the case which seems to present the greatest practical interest—that in which the stator and rotor are connected to the same busbars and in such sense as to give a synchronous speed which is twice that corresponding to the busbar frequency. Operating in this way the machine exhibits a negative damping torque which, in general, decreases with increase in rotor or stator leakage reactance but becomes positive over a small range of values of the coupling coefficient. It appears from the investigation that it is possible to design a motor for operation at the double synchronous speed which shall have a large positive damping torque and which will therefore be stable in operation.

A Simplified Electromagnetic Theory of the Induction Motor, using the Concept of Wave Impedance *Monograph* 283 U

PROFESSOR A. L. CULLEN, PH.D., *and* T. H. BARTON, PH.D.

The authors apply electromagnetic field theory to the analysis of performance of an induction motor rotor when it is exposed to a rotating magnetic field of constant amplitude. An idealized model of the rotor is taken and the analysis is simplified by the application of the concept of wave impedance. The model rotor is capable of simulating the effects of tooth-top and zigzag leakage fluxes but end effects are neglected. The equations of performance thus obtained are shown to be *identical* with those obtained by the conventional theory when the latter includes skin effect. The model motor used by Mishkin is shown to give results widely different from those obtained in practice since it neglects the leakage fluxes referred to above. The analogy between the tangential force acting on the rotor and radiation pressure is indicated, and the authors show that a change of variable familiar in microwave theory leads to the theory of the variable-speed induction motor developed by Williams and Laithwaite.

PAPERS

The Use of Steel-Tank Mercury-Arc Inverters for Generating Medium Frequencies for Induction Heating *Paper* 2457 U: *Part A*

D. L. SMART, B.SC.TECH., *and* J. J. L. WEAVER

The paper presents in a non-mathematical way a general survey of the circuit operation and construction of 6-anode steel-tank mercury-arc inverters for the generation of medium-frequency power, in the output range up to 250 kW at 1–2 kc/s.

The basic operation of the inverter circuit is first described, together with some features of practical inverter circuits, including the problem of starting inversion without modifying or previously exciting the tuned output circuit. The characteristics and limitations of the inverter valve and other main-circuit components are discussed, together with the requirements of different types of melting and billet-heating furnaces.

The problem of designing circuits to meet all the varied control requirements has been met by the development of an electronic grid control unit, which ensures reliable starting and gives facilities for automatic frequency and voltage control.

A general description is given of installations in service for forge heating and melting.

Due for reading in the second half of the session.

Design and Application of Large Solid-Rotor Asynchronous Generators *Paper* 2492 S: *Part A*

P. RICHARDSON

Problems in connection with the design and operation of certain special turbo-type generators have indicated that the characteristics of the asynchronous generator are worthy of consideration. Such generators are not new, but relatively few have been commissioned and these are of small output. They are virtually induction or asynchronous motors, driven above synchronous speed by a prime mover and drawing their magnetizing current from other synchronous machines on the system or from capacitance available therein. The paper deals with the general principles of such generators, followed by a consideration of the characteristics and problems involved in their design, including core end heating and rotor surface heating.

Consideration of the operation of the asynchronous generator enables an estimate to be made of the probable limits of asynchronous heating resulting from loss of excitation on synchronous generators, of the use of asynchronous generators as shunt reactors and their use on the high-speed lines of cross-compounded units.

Due for reading in the second half of the session.

The Application of Digital Computers to Nuclear-Reactor Design *Paper* 2507 M: *Part A*

J. HOWLETT, B.SC., PH.D.

The paper reviews the main computational problems arising in the design of a nuclear power reactor. The numerical-mathematical methods available for attacking these problems are described briefly, and are divided into two broad classes: the discrete-particle (Monte Carlo) treatment of the neutron transport problems and the analytical methods based on the transport equation. The use of electronic digital computers is discussed in general terms, and three examples are considered in more detail: the calculation of the thermal utilization factor for a lattice by the spherical-harmonics method, the direct numerical solution of the two-group diffusion equations for a cylindrical reactor and the calculation by Monte Carlo methods of the resonance escape probability for a graphite-uranium lattice. Finally there is a discussion of the standard of performance of computers likely to be required by nuclear engineers.

Due for reading in the second half of the session.

MONOGRAPHS AND PAPERS (*contd.*)

Magnetic Tape for Data Recording *Paper* 2536 M: *Part B*

C. D. MEE, PH.D.

The occurrence of mistakes, i.e. drop-outs, in the recording and reproduction of pulse signals on magnetic tape is investigated. The author discusses the mechanisms of recording and reproduction for return to zero and non-return to zero recording, and their susceptibility to drop-outs is assessed. Conditions for minimizing the occurrence of drop-outs using conventional recording methods are considered, and new recording systems are suggested and described which a insensitive to the majority of drop-outs.

An experimental test apparatus for detecting drop-o and measuring their size is described which may be used test tape under widely varying conditions of recording. T is used to study the effects of different plastic base mater on tape performance for data recording. The drop-o content of present-day tapes is measured and an economi performance specification is suggested.

To be published on the 8th February and due for reading the second half of the session.

[An additional paper published this month is noted on p. 37.]

Symposium on Long-Distance Propagation above 30 Mc/s

Synopses of the papers to be read at the Symposium on Long-Distance Propagation above 30 Mc/s, which will be held on the 28th January in the Institution building, are given below. They have now been published as separate papers, but they are not available individually, only in complete sets. The price of a set of papers is £1 5s. to members, and £1 15s. to non-members. The complete proceedings of the Symposium, comprising the papers and discussions, will be published as a Supplement to Part B of the Proceedings of The Institution, and an announcement about this will be made in the Journal later. Individual reprints of papers will not be available. All those wishing to attend the Symposium are required to register. *See p. 45.*

Session 1. 10 a.m. IONOSPHERIC FORWARD SCATTER PROPAGATION

Survey of the Gibraltar–United Kingdom Ionospheric Scatter Measurements *Paper No.* 2519: *Part B*

F. A. KITCHEN, B.SC., *and* G. MILLINGTON, M.A., B.SC.

The paper describes the origin of the Gibraltar–United Kingdom circuit working on forward scatter in the ionosphere. Aerial input powers up to 40 kW have been used and observations made on frequencies in the range 37 to 70 Mc/s and at distances in excess of 1 100 miles. The scope of the work undertaken by various interested organizations is outlined and the main conclusions are given in relation to the claims that have been made for this mode of transmission by the pioneer workers in the United States. Special reference is made to the serious interference problems arising from the reception of signals from other stations and noise sources by reflection from sporadic-E ionization, particularly in lower latitudes. Similar troubles, including the effect of back scatter and round-the-world echoes, have been met, owing to normal F-layer reflection as the sunspot cycle has progressed from a minimum to a very high maximum of activity.

A Scatter-Signal Analyser *Paper No.* 2531: *Part B*

P. H. CUTLER, B.SC., *and* D. WILLIAMS, B.SC.

The paper describes a scatter-signal analyser which enables level and time-structure measurements to be made on scatter propagation signals. The analyser consists of several different units, the most important of which is a level comparator of the sampling type whose speed of response is sufficient to deal with the highest fading rates anticipated. The various un may be interconnected in different ways, and the pap explains how the analyser may be used to measure amplitu distributions, median aerial gains, signal auto- and cro correlations, fading rates and, in some circumstances, er rates.

The Choice of Aerial Height for Ionospheric Scatter Links *Paper No.* 2532: *Part B*

E. FITCH, B.SC., *and* R. RUDDLESDEN, M.ENG.

In ionospheric scatter communication systems the angle elevation at which signals should be transmitted and receiv depends on the circuit length, the height of the ionosphe scattering layer and the refraction which occurs in the tropo sphere. The effect of variations of these parameters is di cussed, and it is shown that probable variations of ionosphe height and refraction are unimportant for circuits up to abo 1 100 miles in length.

The concept of optimum height of aerial above a smoo reflecting foreground is introduced and is shown to b applicable to the partially incoherent wave which results fro the scattering process.

The additional question of adequate overlap of tho regions of the ionosphere visible from the transmitting a receiving aerials is considered, leading to recommendatio for circuit design. It is shown that the design of very lo circuits presents difficult problems, and that to secu consistent performance on such circuits it might be advant geous to use two aerial systems at different heights.

The Structure of High-Frequency Ionospheric Scatter Signa *Paper No.* 2529: *Part B*

D. WILLIAMS, B.SC.

The paper reports measurements of amplitude distributio lateral correlation, diversity effects and error rates of ion spheric scatter signals at a frequency near 70 Mc/s. The resul are discussed and it is concluded that a markedly no Gaussian signal occurs at some times. The effects of sign structure are examined, and it is shown that the only effe is that some loss of diversity action would need to be includ when deducing the performance of a link from the medi signal and noise levels. The signal/noise ratio required f various error rates in a non-diversity system is derive together with information of use in estimating the feasibili of h.f. communication links. Some information on the diurn variation of cosmic-noise intensity is given.

Radio Interference as a Factor in Ionospheric Scatter Communication *Paper No.* 2527: *Part B*

G. A. ISTED

The problem of radio interference is particularly acute when consideration is being given to ionospheric scatter communication. This is mainly brought about because of low-average-scatter signal intensities, and the consequent need for high-gain receiving aerials.

A wide variety of both man-made and natural interference has been encountered in the United Kingdom during an investigation into the behaviour of scatter transmissions from Gibraltar. Furthermore, specific surveys have been made which have yielded valuable information concerning disturbances at other geographical locations.

The problem resolves itself mainly into two categories: (*a*) disturbances which have their sources in the vicinity of the receiving aerial, and (*b*) disturbances which are propagated over great distances. Type (*a*) can be largely overcome by adequate separation of the receiving site from disturbing sources, and by careful design of the receiving aerial; type (*b*) could be overcome by raising the operating frequency.

Analysis of Gibraltar–United Kingdom Ionospheric Scatter Signal Recordings *Paper No.* 2523: *Part B*

G. A. ISTED

The variation of ionospheric scatter signals received at East Hanningfield, Essex, from the experimental transmitter at Gibraltar has been analysed, but, because of some disturbing factors, great care has had to be exercised in accepting certain recordings.

In general, the mean signal levels are a maximum between 0400 and 1 200 G.M.T., while a fairly well-defined minimum occurs at about 1 800 G.M.T. Signal bursts of duration greater than 1 min appear to have a diurnal variation similar to that of the observed mean signal levels.

The time relationship between the first appearance of an identifiable burst at two receiving stations separated by a distance of 70 miles has been investigated. On an east-west route the mean lag at the west station is just over 2 min, the range being from +11 to −6 min; the latter represents a lag at the east station. A pronounced seasonal variation in mean signal levels has been disclosed by the analysis. Two sharply defined minima occur, one centred on March, the other on October; of the two maxima, that which occurs in December is the higher.

The variation of transmission loss with frequency derived from the analysis confirms the American data obtained at a similar mean latitude. Compared with 37 Mc/s, the mean signal levels for corresponding months show a reduction of 10 dB for 48 Mc/s and 19 dB for 70 Mc/s.

Polar-Diagram Requirements for Aerials for Communication by Ionospheric Scatter *Paper No.* 2516: *Part B*

D. H. SHINN, PH.D.

The required polar diagram of the aerials for ionospheric-scatter communication depends on four factors, namely the size and shape of the zone in the ionosphere which can be seen from both terminals, the effect of the angle through which the radiation is scattered, the allowable multi-path delay and the interference. Diagrams showing the mutually visible zone are presented for path lengths between 1 200 and 1 800 km. The available information on the scattering properties of the ionosphere suggests that there is not much advantage in reducing the beam width in the horizontal plane below about 30°. The required polar diagram in the horizontal plane is discussed in detail for a path length of 1 200 km. For the polar diagram in the vertical plane it is important to ensure that the lowest lobes from each terminal overlap well, and that as much power as possible goes into the lowest lobe. Rules for achieving this are given, and protection against interference to or from distant stations is discussed. The author investigates requirements for the reflecting surface (land or sea), and shows that horizontal polarization is preferable; the size and allowable roughness of the surface are specified.

The Angular Distribution of Energy Received by Ionospheric Forward Scattering at Very-High-Frequencies *Paper No.* 2487: *Part B*

W. C. BAIN, M.A., B.SC., PH.D.

A study has been made of the angular distribution in the horizontal plane of the energy reaching Slough from a v.h.f. transmitter at Gibraltar by scattering in the ionosphere. The mean bearing of the energy distribution is found to vary with time of day, and is, on the average, zero in the middle of the day and 7° west by night with reference to the great-circle path. The spread in bearing of the incident energy at any time has a standard deviation, with a mean value of about 6°.

The Direction and Amplitude of Reflections from Meteor Trails and Sporadic-E Ionization on a 1 740 km North-South Path at Very-High-Frequencies *Paper No.* 2537: *Part B*

R. W. MEADOWS, B.SC.

The paper reports measurements made at Winkfield, near Slough, on signals received from a transmitter at Gibraltar operating on 37·3 Mc/s. A diurnal variation of the mean bearing of meteor-trail reflections is found, and the angles of elevation are consistent with those to be expected from the path geometry. The rates of reception are found to be consistent with an inverse amplitude law for the weaker reflections and with an inverse fourth-power law for the strongest. The bearing of the strong persistent reflections obtained from sporadic-E ionization lies close to the great-circle bearing. Applications to practical transmissions are briefly considered.

Short Bursts of Amplitude of a 50 Mc/s Wave received over a Distance of 480 km *Paper No.* 2530: *Part B*

G. S. KENT, B.A.

Observations have been made on short bursts of signal received at Cambridge from the Kirk o' Shotts television transmitter at a distance of 480 km. The time distribution, the distribution of amplitudes and the direction of arrival of these bursts are studied. The characteristics which would be expected if the bursts were produced by reflections from ionized meteor trails are examined and good agreement is found between these and the experimental results.

Amplitude of Very-High-Frequency Signals Reflected from the Sporadic-E Layer in North-West Europe *Paper No.* 2514: *Part B*

P. J. BRICE

Measurements have been made at Banbury over a period of a year of the strength of the high-level signals occasionally

received from an Iceland transmitter operating on a frequency of 37 Mc/s. The results have been analysed and used to prepare curves of the estimated quasi-maximum values of field strength likely to be received over distances of 700–2000 km in north-west Europe and for frequencies of between 30 and 70 Mc/s.

Session 2. 2.30 p.m. TROPOSPHERIC PROPAGATION BEYOND THE HORIZON I

Guglielmo Marconi and Communication Beyond the Horizon: A Short Historical Note *Paper No.* 2479: *Part B*

G. A. ISTED

The paper describes experiments, carried out between 1928 and 1936 by Guglielmo Marconi, which demonstrated that transmission beyond the horizon by means of microwaves was practicable. Furthermore the influence of tropospheric mechanisms on radio-wave propagation was recognized by him at the time.

A Survey of Tropospheric Wave Propagation Measurements by the B.B.C. 1946–1957 *Paper No.* 2517: *Part B*

R. A. ROWDEN, B.SC.(ENG.), L. F. TAGHOLM *and* J. W. STARK

The paper describes beyond-the-horizon tropospheric wave propagation measurements made by the B.B.C. Research Department during the years 1946–1957. Initially, the data were used to assist the B.B.C. in planning common-frequency working within the United Kingdom for v.h.f. sound broadcasting and television, and later became a contribution towards the collection of data organized internationally by the C.C.I.R. and used by that body in the preparation of field-strength/distance curves representing average tropospheric conditions.

The Measurement and Prediction of V.H.F. Tropospheric Field Strengths at Distances Beyond the Horizon *Paper No.* 2500: *Part B*

J. K. S. JOWETT, B.SC.(ENG.)

After a brief historical review of theoretical and practical deductions concerning the characteristics of v.h.f. tropospheric propagation beyond the horizon, the author describes a series of measurements made since 1948 by the Post Office at receiving sites within the United Kingdom. Particular attention is given to the concept of angular distance and to the effect of path profile on the median levels of field strength, as well as upon the range of fading observed. Simple transmission laws deduced from the observed data enable empirical curves of field strength versus distance to be drawn for various percentages of the time.

The Effects of Atmospheric Discontinuity Layers up to the Tropopause on Beyond-the-Horizon Propagation Phenomena *Paper No.* 2486: *Part B*

B. J. STARKEY, DIPL.ING., W. R. TURNER, M.SC., S. R. BADCOE, B.SC., *and* G. F. KITCHEN

Field-strength measurements at distances extending far beyond the horizon from a transmitter on a frequency of 91·3 Mc/s have been carried out in an aircraft flying at heights of about 10000 ft.

It is shown that the experimental data can be explained more readily on the assumption that the mechanism of tropospheric propagation over such distances is due t reflections from discrete discontinuity layers in the atmosphe up to the height of the tropopause, than by the theory forward scatter due to turbulence.

Some Investigations of Metre-Wave Radio Propagation in t Trans-Horizon Region *Paper No.* 2509: *Part B*

F. A. KITCHEN, B.SC., E. G. RICHARDS, M.SC., *and* I. J. RICHMON B.SC.

Investigations have been made of the characteristics of met radio transmissions in the trans-horizon region, at ranges to 400 nautical miles. These indicate the essentially continuo existence of troposphere-supported signal components in th region, although their detailed characteristics are subject variations.

Under particular meteorological conditions, such as th formation of an elevated inversion layer, an addition propagation mode is present, leading to a composite signal intermediate ranges.

Session 3. 5.30 p.m. TROPOSPHERIC PROPAGATION BEYOND THE HORIZON

Propagation Measurements at 3480 Mc/s Over a 173 Mile Pa *Paper No.* 2510: *Part B*

B. C. ANGELL, J. B. L. FOOT, W. J. LUCAS, M.SC., *and* G. THOMPSON, B.SC.(ENG.)

The paper presents an account of an experimental study beyond-the-horizon radio scatter propagation at a frequen of 3480 Mc/s over a path of 173 statute miles between St Point and Wembley. Details of the path and brief details the transmitting, receiving and recording equipment are give

Propagation data, collected from May 1956 to April 195 are presented. The performance of the link is measured the hourly median transmission loss L, defined as the rat expressed in decibels, of the power transmitted to th received. The diurnal and seasonal variations in L a discussed. The distribution of the amplitude of the receiv signal within a period of an hour is used to investigate t characteristic rapid fading of the scattered signal. So attempt has been made to associate variations in L wi general trends in the weather.

The authors give experimental estimates of the aer coupling loss and compare them with various theoreti predictions. Preliminary measurements on double diversi with aerials which can be separated in the vertical direct by distances varying from 9 to 17 ft, are reported.

The effects produced by aircraft flying through the be are discussed, and a series of tests in which a naval aircr flew both along and transversely across the transmission pa is described.

Some Tropospheric Scatter Propagation Measurements a Tests of Aerial Siting Conditions at 858 Mc/s

Paper No. 2528: *Part B*

G. C. RIDER

A tropospheric scatter link has been in operation for th months over a 98-mile path and for eight months over 200-mile path at a frequency of 858 Mc/s. Received signa are shown to agree well with predictions of mean leve whilst seasonal and diurnal variations are slightly less th

was anticipated. Height/gain and space-diversity tests are described, and a comparison is made of signals received at four sites of very different aspects within the same locality. The fast fading is described in terms of fading range and fading rate, and an effort is made to relate this information, together with the slower changes, to meteorological observations. A programme of synchronous beam rotation has been carried out, and tests of received polarization show the polarization to be well preserved in propagation. The disturbing effect of local flying is investigated and discussed.

The Long-Range Propagation of Radiowaves at 10 cm Wavelength *Paper No.* 2522: *Part B*

W. R. R. JOY, B.SC.(ENG.)

A survey is presented of the results obtained in a series of short-term experiments on the propagation of 10 cm radiation over clear sea paths to distances well in the diffraction region, under a variety of weather conditions. Very slowly attenuated signals have been received consistently, under normal atmospheric conditions, from an initial threshold beyond the horizon when the diffracted signal is some 50 dB below the corresponding free-space level. Analysis of the amplitude distributions of some of the received signals confirms that propagation to ranges in the extra-diffraction region was due to a scattering process.

Radio Propagation far beyond the Horizon at about 3·2 cm Wavelength *Paper No.* 2538: *Part B*

W. R. R. JOY, B.SC.

A series of measurements on transmissions of 3·2 cm wavelength at ranges far beyond the radio horizon has been made over various paths, at arbitrary periods of time. These have established the existence of an essentially permanent extra-diffraction signal field. Whilst its level does not change appreciably with time, the character of this signal can vary from that typical of a scattering process to that due to a coherent mode of propagation. Further, although the observed signal attenuation rate with distance is similar to that expected for a scattered field, the average level is found to be some 10–15 dB below that predicted from theory. There appear to be factors affecting the long-range propagation of 3·2 cm waves through the lower atmosphere which are incompletely understood. Although no extensive analysis of meteorological conditions has been made, there is some evidence to show that the existence of extensive well-pronounced anticyclonic systems results in poor propagation conditions for the extra-diffraction signals.

A Review of Tropospheric Scatter Propagation Theory and its Application to Experiment *Paper No.* 2534: *Part B*

H. A. JOHNSON, M.A., B.SC., PH.D.

A comprehensive review is made of published work on the theory of beyond-horizon propagation of radio waves by means of oblique scattering from randomly-distributed irregularities of refractive index in the troposphere. A scattering theory is formulated which attempts to take as accurate account as possible of all effects likely to be important in practice, consisting of some new results combined with the best features of existing theories. Application of this theory to a variety of experimental results yields generally good agreement. Possible causes of some discrepancies, and the likely relative importance of scattering and certain other long-distance propagation mechanisms, are discussed.

The Estimation of Transmission Loss in the Trans-Horizon Region *Paper No.* 2521: *Part B*

E. G. RICHARDS, M.SC.

The expression for the scattering cross-section derived by Batchelor has been integrated over the useful scattering volume for transmitting and receiving aerials aligned on a great-circle path, and formulae have been derived for the transmission loss. The application of the theory to experimental results at 86, 3000 and 10000 Mc/s suggests that mean-square variations of refractive index of the atmosphere may be independent of height up to about 2200 ft and may then vary with the inverse square of height.

The following paper will also be published this month.

A Ferrometer for the Determination of the A.C. Magnetization Curve and the Iron Losses of Small Ferromagnetic Sheet Samples *Paper No.* 2482 M: *Part A*

PROFESSOR H. BLOMBERG, D.SC., *and* P. J. KARTTUNEN

The paper describes the design and properties of a ferrometer for measurements on small (about 30 mm × 200 mm) ferromagnetic sheet samples.

OBITUARY

JOHN HENRY CHARLES SPINKS

The death occurred suddenly at his home on the 17th September 1957 of John Henry Charles Spinks, who was born in India on the 16th February 1899. He was educated at Lawrence School, Simla Hills, India, and received his technical education at the Thomason College of Engineering, Roorkee, where he obtained a certificate in electrical engineering. His course was interrupted for a year in 1918–19 by service in the Indian Army as a Second-Lieutenant.

In 1920 he came to this country to begin a two-year college apprentice course with the Metropolitan-Vickers Electrical Co., and at the end of it he joined the Motor Engineering Department of the company as an engineer. His main interest in the design of electrical machines centred on induction motors, and since 1949 he had been in charge of the Induction Motor Design Section.

In his later years Mr. Spinks had been prominently associated with standardization of electrical machines and had worked enthusiastically on the B.E.A.M.A., B.S.I. and I.E.C. Committees to which he had been appointed. He was a member of the B.S.I. main Committee on Rotating Electrical Machines (ELE/1) and was Chairman of various other B.S.I. Committees. He was also Chairman of two I.E.C. Committees, on Rotating Electrical Machines and Classification of Insulating Materials, and Chairman of two B.E.A.M.A. Committees. Numerous tributes from his colleagues on the various committees show how highly his work was regarded.

At home he was a very keen gardener and always had a lively interest in natural life. He was quick to notice and comment upon any unusual plants and birds, and one could sense his enjoyment of such matters—things which many of us never see. He was also fond of music, both orchestral and operatic, and was very knowledgeable and interesting on the subject.

His was a most courteous and kindly nature, and he had a cheerful and friendly manner to all. He was a most conscientious and loyal worker, always ready to be helpful and to give advice however busy he happened to be. Many engineers have much to thank him for in their early years of training. He will be very sadly missed by the wide circle of friends he made, and during the course of his career he made many in the engineering world. He is survived by his widow.

Mr. Spinks joined The Institution as an Associate Member in 1928 and was elected a Member in 1949. A. G. W.

Elections and Transfers

The following elections and transfers approved by the Council are effective from the 7th November 1957.

ELECTIONS

Graduates

AIKEN, Aubrey Donald
AITKEN, Fred Meekison
ALLERSTON, Harold George Dyer
ALLISON, Walter
AMON, Emmanuel Ayodele
ANDERSON, Robert
ANSARI, Iqbal
ARCISZEWSKI, Henryk, B.SC.(ENG.)
ARNOLD, Ronald John Kendal
ASHFORD, Brian Philip
ASKIRA, Muhammed Tata
ATKINSON, John Derek
BAILEY, Michael John
BAKER, Geoffrey
BALCOMBE, Dennis Albert
BARNETT, Martin Sydney
BARRY, Alan Frederick
BELFORD, Timothy Morton
BENNETT, Roy James
BERLOCK, Monty David
BEVERIDGE, Andrew
BLOCH, Cyril Ettienne, B.SC.(ENG.)
BOLTON, Alfred Thomas
BOND, Norman Ward
BOTTOMS, Frederick Alexander
BRETTON, Kenneth Martin
BROOKE, Thomas Joseph
BROWN, Leonard
BRYON, Terence Norman
BUNN, William John
BURBECK, Ronald Noel
BURLING, Kenneth George
BURNS, Robert Cooper
CALVER, Brian
CARGILL, George Smith
CARTER, Keith Richard Frank
CARTER, Stanley
CATTO, John Duncan, B.E.
CAULTON, Bernard
CHAKKO-GEORGE, Mohan Jacob, B.A.
CHAPMAN, Robert Francis
CLAPP, Raymond George
CLARKE, Robert Thomas
CLEMENTS, Brian Geoffrey
COARD, William Derek
COATON, James Richard
COCKERHAM, Hubert
CROWE, Victor Eric
CURRIE, Donald
DAVIES, David Gore Ashton
DAVIES, Donald Wynn
DAVIES, Marcus
DOWN, John Otto
DOWSETT, Peter Howard, B.SC.
DUFF, Geoffrey Ernest
DUFFY, Patrick Stephen John
EASTERBROOK, Bernard James
ECCLES, James Edward
EVANS, George Gwynfor
EVANS, Kenneth Alfred
FINCHAM, Kenneth Harry
FRASER, Jack Stanley
FREEMAN, Keith Osborne
FREND, Dermot Neville
GANN, Graham Dean, B.E.
GARDENER, Gordon Hector
GILES, Peter Michael
GLADMAN, James Edwin, B.SC.(ENG.)
GOUR, Prakash Narayan, B.SC.
GRAHAM, John Foster
GREENWOOD, John Dewhirst
GRIGGS, Arthur Frederick
GRIGSBY, John Walter
GROSE, Maurice Alan, B.SC.(ENG.)
GUEST, Alan.
HAMSHERE, Albert Alfred
HARRELL, Claude Victor
HERSEY, Alan Walter
HIETT, Peter
HILL, Ronald George
HINCHLIFFE, Philip
HISCOX, Edward Roland
HOBSON, Ralph
HOLMES, Alan
HOPKINS, Ronald James
HOPKINSON, Roy
HORSLEY, John Francis
HORWOOD, Gordon
HOTHAM, Alec, B.SC.
HOWARD, David
HUNT, Cyril
INMAN, John Graham
JACKSON, Leon
JEFFERY, Gerald Victor
JOHNSON, James
JOHNSTONE, Ian
JONES, Henry Oliver
KUBANJE, Edin Eden
LAHIFF, Dermot Joseph, B.E.
LAMB, Leonard Cecil
LANE, Thomas Ernest
LAURENCE, Raymond John
LAWRENCE, Anthony Edward
LE BUTT, Brian Edward, B.SC.(ENG.)
LEIGHTON, Ronald
LEWIS, David Michael
LOFTUS, Desmond Samuel
LOUCH, Ronald David
LUCAS, Alan John Empson
LUXON, Keith Kenneth
MACDONALD, Iain Huisdean, B.SC.
MCGREGOR, Cyril Raymond
MACHIN, Geoffrey
MCINTOSH, William Alfred
MCKINNEY, Raymond
MCLEAN, Kenneth James, B.E.
MANN, George, B.SC.
MARSDEN, Tom
MATHEWS, Maurice James
MATTHEWS, Robert George
MESSAGE, Flt.-Sgt. Stanley George, R.A.F.
MILLWATER, Milson Clifford
MINTER, Ronald Henry
MOFFAT, Thomas
MOOR, Christopher, B.A.
MOOREY, John Arthur
MYERS, John Alfred
NEALE, Peter John
NUTTER, John Lawrence, B.E.
NZEGWU, Theophilus Ifeanyi Ofili, B.SC.(ENG.)
O'KEEFFE, William, B.E.
OLSCHER, Wilfred Gerhard, B.A.
ORAM, Alan
PARRY, John
PARSONS, Lionel Charles, B.E.
PASKINS, David Cecil
PEGG, William Frank
POWELL, John William
PRATT, David Keith
PRATT, John Michael Keith, B.SC.
PUNSHON, Alan
PURNELL, John Arthur, B.E.
RAJADHYAX, Laxman Mangesh
RAMSAY, Donald Charles
RAFLEY, Joseph Kenneth
RAY, Eric
READ, Victor John
REDPATH, John Kenneth
RICHARDSON, John Dalkin
RIGBY, John
ROBERTSON, Harry
SALT, Kenneth John
SAPSFORD, George
SAVVA, George
SCOTT, Ian Wallace
SCOTT, James Henry
SCRIMGEOUR, James Alexander
SHAMMAS, Alif Salim
SHELDON, John Reginald
SHIELDS, John Philip, B.SC.
SHINKFIELD, Roger John, B.E.
SHUFF, Ronald Stanley
SING, Arllen
SKINNER, Sydney Lonsdale
SLACK, Billy
SMITH, Capt. Brian John, B.SC.(ENG.), R.E.M.E.
SMITH, John Edward
SMITS, Aivars
SNELL, William Tysoe
SNOOK, Albert Thomas
SOOD, Vidya Sagar, B.SC., B.SC.(ENG.)
SPRAGGONS, Victor
STANBROOK, John Alfred
STEEL, John Greenly
STRINGER, Michael
STUART, Roy Archibold Alfred
STURGESS, William Henry
SUMMERS, Raymond Edgar
TAMS, Kenneth William
THOMAS, Godfrey
THOMAS, Gordon Frederick
THOMPSON, David Cyril
TICKNER, Derek Charles
TIE TEN QUEE, Paul
TOMASSON, Olafur, B.SC.
TOPP, Ivor Bernard
TRIM, Lucien Albert Joseph
TUNNICLIFFE, Neville
VAWSER, Keith Derwent, B.E.
WALKER, Frederick, B.SC.
WALLIS, Alan George
WARMOTH, Denis
WARREN, Kenneth Roy
WATSON, Benjamin
WHITEHOUSE, Hubert David
WHITFIELD, Keith Alexander
WILLIAMS, Sydney Charles
WILLSON, Kenneth Alan
WILSON, Gordon Hugh Fox
WITHERS, Brian Neville
WOOLLEY, Bryan James

Students

AHAMED, Syed Vickar, B.E.
AJAYI, Olugbenro Adeyemi
AKHTAR, Abdul Sattar
BRODIE, John Herbert, B.SC.
BURNETT, Norman Alexander MacAlpine
Carley, Robert
DE SOUSA, Carlos Mussolini
ESTERSON, John Michael, B.SC.
FARHI, Marc Ernest, B.SC.(ENG.)
FONSEKA, Wanniarachchige Roland
GALLAGHER, Michael Joseph
GUNASEKERA, Wallace Samarasinha
HARRIS, Stuart Hardie
HEARN, Anthony George
HILL, Clive William, B.SC.
HURL, Malcolm Rodney
JACKSON, Brian
JENKINS, John
KAMALANATHAN, Sivagurunathar
KARCHAUDHURI, Sudhansusekhar, B.SC.
KNAPP, Raymon
LEE, Wing Kee
LYON, Derek Charoes, B.SC.
MAHENDRAN, Paramoo
MANN, Michael George, B.SC.(ENG.)
MATTHEWS, Frederic Gordon, B.SC.(ENG.)
MAWLEY, Vishwanath Narayan
METTANANDA, Asoka
MOORE, Bryan
MORRIS, George Edwin, B.SC.
NORTON, John
PATCHETT, Bernard John
PATEL, Jashbhai Shankerbhai, B.E.
PATEL, Thakorbhai Umedbhai, B.E.
PAYNE, David John
PILKINGTON, Donald James, B.SC.
PRICE, Maurice Edward
RALPH, David Godfrey
RANDERI, Narendra
RAO, Gurpur Koladabadi Radhakrishna
RICHARDSON, Robert
RILEY, John Ashley
ROBSON, Brian, B.SC.
SMITH, Philip John Mytton
SOYSA, Warusahannadige Neil, B.SC.
SPIRLING, Thomas John
SUDWEEKS, Richard William
TAMBE, Pratap Shripad, B.SC.
TAN, Kiah Tong
TATE, Peter Anthony
TEO, Chye Poh, B.SC.
VAN BAARS, Gerald
VAN DER WESTHUYZEN, Johannes Petr
WHITE, James Trevor
WHITE, Joseph Edward Dixon
WIJAYATILLEKE, Don Gilbert Dharmasena
WOODGER, Peter

TRANSFERS

Student to Graduate

ADAMS, John Andrew
ADAMSON, Sub-Lt. Robert Vaudrey, B.A., R.N.
AKERMAN, John Michael
AMOR, Cecil Frederick
ARNOLD, Vaughan, B.SC.(ENG.)
ASHLEY, John David
ASHTON, Derek Cyril
ASHURST, Fred
AYLING, Stanley Gerald
BAGOT, William Arnot
BAILEY, Robin Andrew, B.E.
BAKER, Philip Davall
BELL, Ernest Clifford, B.SC.(ENG.)
BENNELL, David Walter, B.SC.
BILLINGE, Peter Louis, B.SC.
BOTTOM, John Robin, B.SC.(ENG.)
BRETT, Robert Frank
BRIGGS, Neville
BRIMELOW, Peter
BROCKWELL, Kenneth John, B.SC.
BROOKER, Reginald Douglas
BROOKS, Ronald Clifford
BROWN, Frederick
BRYANT, Walter Edward
BURROWS, Michael Leonard, B.SC.(ENG.)
BURTON, Ivor Stewart
CARTER, Ronald Philip, B.SC.TECH.
CARTWRIGHT, William
CHAMBERLAIN, John
CHAPMAN, John
CHARLES, Ivo John
CHILD, John David, B.SC.
CHRISTOPHER, Kenneth Charles
CLARK, John Stewart
CLUETT, Gonzalo William John
COBB, Roland Roebuck
COLLIE, Arthur Alexander, B.SC.
COLLIS, Reginald Edward
CROSS, Peter James
DIKKO, Yahaya Abdurrahman
DINES, Paul
DOGGETT, Peter Edward
DONE, Clifford Graham
DULLEY, Peter John
ERDEN, Dogan, B.SC.
EVANS, Clifford
EVELEIGH, Ronald David
EYLES, Edwin John
FARR, Charles John, B.SC.(ENG.)
FERBER, John Frederick
FOXON Derek
FULLER, Marcel
GALLOWAY, Fred
GANE, Alan Ernest
GHOSH, Asoke Kumar, B.SC.(ENG.)
GIRDLER, John
GOODCHILD, Albert David John
GREEN, Leonard Andrew
GREEN, Leslie John

Student to Graduate (contd.)

GRIFFITHS, Derrick Thomas
HALL, Arthur Conway
HARDMAN, Edmund Peter, B.SC.(ENG.)
HARMSWORTH, Jack Albert
HARVEY, Anthony Thomas
HEATON, Geoffrey
HEWITT, Patrick John
HICKS, Donald Keith
HOBBS, Alan James
HOLLIDAY, Bryan
HOLLOWAY, Peter Joseph
HOLMES, John Nicholas, M.SC.
HOLMES, Robert Thompson, B.SC.
HOWARD, John Howard
HUGHES, John Robert
HUNT, Peter Brian, B.SC.
INGHAM, Jeremy Colin, B.SC.(ENG.)
JACKSON, Hedley Colin
JEBB, Alan, B.SC.
JENKINS, Harding Meredith, B.SC.(ENG.)
KEEN, Peter Edward Roland
KING, Michael Harold Ross, B.SC.(ENG.)
LAMKIN, Geoffrey Antony
LANGFORD, John Ian
LATIMER, David William Milton, B.A.
LEWIS, William Peter
MACKINNON, Ian Alexander, B.SC.
MCROBB, Neil Farquharson, B.SC.(ENG.)
MALONEY, Terence
MARSHALL, Derek
MILES, Robert Sidney
MUIR, Wallace William
NAGY, Andrew Francis, B.E.
NEWMAN, John Gordon
NICHOLSON, Geoffrey Bailey
NRI, Cyril Onuora
NUNNELEY, John Charles Balmayne
PATEL, Shantilal Tribhovandas
PAVIOUR, Edwin
PAYNE, David John
PAYNE, David John
PEET, John, B.SC.(ENG.)
PHELPS, John Keith
PHILLIPS, David Stuart
PHILLPOTTS, Leslie Howard
PILLING, Harold William Cliff, B.SC.TECH.
PRITCHARD, Ronald Sidney, B.SC.(ENG.)
PROCTER, Frank Edward
PUGH, Alan, B.SC.
REAVILL, Barry
REED, Geoffrey Alexander Leslie, B.SC.(ENG.)
ROCHE, John
ROCKY, Michael Stanley
RODDY, Gerald Francis
RYAN, Frank Leonard
SANDERS, Edward Thomas
SAUNDERSON, Anthony David
SHACKLETON, John Michael, B.SC.
SKINNER, Samuel Edward, B.SC.(ENG.)
SPENCER, Arthur James, M.A.
SPINKS, David
STANLEY, Graham Edward
STEVENSON, William Gray
STRONG, Robert
TAYLOR, Gordon
THEOBALD, Ivan Spencer
TODD, Barrie John
WALES, John Richard
WAYE, Jack
WEBB, David
WEBSTER, Alan Henry
WEDLOCK, Thomas James
WELLINGS, Donald Clive
WELLS, Maurice
WHITLOW, Colin Hubert
WICKEN, Clifford Stanley
WILSON, Ian
WOOD, John Irwin
WRIGHT, John Peter
WYKE, Cyril Brian
YOUNG, Derek Albert

The following elections and transfers approved by the Council are effective from the 2nd December 1957.

ELECTIONS

Associate Members

BARHAM, Donald William Collington, B.SC.(ENG.)
BLAIR, David Gordon, B.SC.TECH.
BROWNING, William John Cowan
BROUCHMAN, Ernest Leslie
COWWEATHER, Frank, B.SC., PH.D.
GHASSEMIAN, Abbas, DIPL.ING.
GILLMAN, George Godfrey
GRAINGER, Frank
HOGG, David Dorward, B.SC.
KHAN, Abdul Hameed, B.A., B.SC.(ENG.), M.A.SC.
LLOYD, Dennis Arthur, B.SC.
MCCANN, David Band
MARSHAM, Thomas Nelson, B.SC., PH.D.
MCEACHERN, John Martin, B.E.
NICHOLS, George de la Mare, B.SC.(ENG.)
PARRY, Charles Alchorne
PRESTON, William John
RAE, William Ian Lorence
STRINGER, Harold
SUD, Indar Sain, B.SC.(ENG.)
SWANN, Henry
THOMPSON, James
THOROGOOD, Dennis
WALSH, William
WHITEHEAD, Geoffrey Herbert
WIGHTMAN, Eric Jeffrey
WURR, John Cecil, M.A.

Associates

ARCHENOUGH, Arnold
BROWN, Allan
GHISNALL, William Edward
HAYTHORNTHWAITE, Hubert
KASED, Hosheng Hormasji
MONRO, Alfred James
PRICE, Norman Rookby
SHARPLEY, Walter Albert
SPENCER, Bernard John Charles
SWAN, Sqn. Ldr. William, R.A.F.
YOUDAN, Denis

TRANSFERS

Associate Member to Member

ARNOLD, William Eli
BELSEY, Frederick Harold
BLAKELEY, Philip William
DAWSON, Stanley
EVERSHED, John Dendy, B.SC.(ENG.)
GRAINGER, Ernest James, M.SC.
HARDY, Henry Cyril
HENLEY, William Ronald
KREBS, Ernst Wolfgang, DIPL.ING.
MOES, Gerlacus
MONEY, Stewart Henry
OXFORD, Alan John Henry, B.SC.
PARKIN, Geoffrey William, M.ENG.
ROSS, William, M.A.

Associate Member to Member (contd.)

SPENCER, Gordon Arthur
STAFFORD-GAFFNEY, Lt.-Col. William Nicholas, B.SC.(ENG.), R.E.M.E.
STEBBING, Geoffrey Charles
TAYLOR, Leonard Francis, B.SC.(ENG.)
TEE, James Victor, B.SC.(ENG.)
THOMAS, George Edwin Threapland
THOMSON, William Charles, B.SC.(ENG.)

Graduate to Associate Member

ALAGARATNAM, Candiah, B.SC.
ALLUM, David Albiston, B.E.
ANDERSON, William Douglas Laing, B.A.
ANDREW, Peter
ASKEW, William
ASTRAEOS, Paul Theodossios, B.ENG.
BAULDREAY, John, B.SC.(ENG.)
BLACK, Stewart Carstairs, B.SC.
BRACKLEY, Kenneth Joseph
BREALEY, Alan Donald Robert, B.SC.(ENG.)
BUELL, Devavardhar, B.SC., B.SC.(ENG.)
BYFORD, Gordon Holt
BYRD, David John Powell, B.SC.
CALTON, Ernest
CHADWICK, James Schofield, B.SC.
CHANDLER, David Edward Ernest, B.SC.(ENG.)
CHRISTIE, William Crearer
CRICK, Richard Edward Roland
DALLOW, Raymond William
DALTON, Oliver
DAVIDSON, John Frederick, B.SC.
DEMAINE, Harry
DENISON, Edmund, B.SC., B.SC.(ENG.)
DUNN, Frank
FATEHCHAND, Ramdas Richard Thakurdas, B.SC.(ENG.), PH.D.
FERNANDO, Ira Barry Evertsz
FISHER, John
FITZSIMONS, Henry
FOSTER, James Henry, B.SC.(ENG.)
FOWLER, Eliot Patrick, M.A.
FRANGINI, Robert Louis, DIPL.ING.
FRENCH, George Henry
GILMOUR, William Dudley, B.A.
GORDINE, Rafield Barry, B.E.
GOVE, Robert Morrison, B.SC.
HALI, Harry Sydney
HARDMAN, Robert Ian
HAYES, Douglas Percy
HEMMINGS, Robert Frederick, M.A.
HENDERSON, Frederick
HORNER, Walter
HOYLE, Robert Harold Dickon, B.SC.TECH.
HUGHES, Owen Idris
HULL, James
IPSEN, Roy
JONES, Daniel, B.SC.
JONES, Edward Raymond, B.SC.
KENNERLEY, Francis Roy, B.E.
LEACH, George
LEES, Alan Barnhart, M.SC.TECH., PH.D.
LEEVERS, Kenneth Norman
LIFELY, William Michael
LINDSAY, Louis Stradling
LONGMAN, Peter Henry, B.SC.(ENG.)
LOWMAN, Anthony John
MCGREAL, Patrick Stanley Michael
MARSHALL, John
MARTIN, Arnold Marshall, B.SC.
MARTIN, Raymond Gerald, B.SC.(ENG.), B.SC.
MUIR, David George, B.SC.TECH.
MYERS, Harry, B.SC.
NAJMABADI, Farrokh, B.SC.
NEGUS, Arthur John, B.SC.
NIXSON, James Mayer
PAYNE, Alister Arthur Sinclair, B.SC.(ENG.)
PHELAN, Richard Daniel
POLLARD, Eric, M.SC.
PORTER, Howard Colin, B.A.
POTTS, Tom Baxter, B.SC.
RIPPON, Kenneth Philip, M.A.
ROBINSON, William Adam
ROGERS, Herbert, B.SC.
RUSSELL, Derek Barry, B.SC.(ENG.)
RUTTER, Marshall Sorley
SHARPE, Peter James, B.E.
SHERRY, Alan, B.SC.
SHIU-WAI, Au, B.SC.(ENG.)
SKUSE, Victor Ernest
SMITH, Ronald Edward
SPEIGHT, Laurence Harry, B.SC.(ENG.)
STEELE, Francis Howard, B.SC.(ENG.)
SUTHERLAND, Sidney Henry John, B.SC.(ENG.)
TAYLOR, David George, B.SC.(ENG.)
TAYLOR, Robert Douglas
THOMSON, Kenneth John Hewan, B.SC.(ENG.)
TREECE, Douglas Rex
TYACKE, Stanley William
WALLACE, Nelson Griffith
WARING, Eric
WARWICK, Alan Rowland
WHEELER, Donald James
WINTERBOTTOM, John, B.SC.
WYLIE, Geoffrey Arnold, B.SC.(ENG.)
YOUNG, Thomas Andrew Marks

The following elections and transfers approved by the Council are effective from the 5th December 1957.

ELECTIONS

Graduates

ALLAN, Robert Joseph
ALLEN, Douglas Cooper
ALLMAN, Dennis
ANDREWS, Henry James
ASHTON, Edward George
ASHWORTH, Harry
AYLING, John Kenneth
BAILEY, John Milne
BAKER, Peter Norris
BAKER, Peter William
BALAAM, John James
BALL, Derek Stanley
BANTON, Douglas Arthur
BARCLAY, Deryk Neville
BARDOS, Imre
BARKER, Peter John
BARNWELL, George Henry
BARROW, Stanley
BEGLEY, James Anthony Gerard
BELL, Edward Darroch
BENNETT, Colin Peter
BENNETT, Raymond
BERRY, Arthur Albert
BERRY, Keith
BETTISON, John Maurice
BIRD, Robert John
BLAGRAVE, Reginald Francis
BLAIR, David Thomas Alexander, B.SC.(ENG.)
BLICKETT, Douglas Stanley
BLUNDY, Robert William
BOWEN, Julian
BOYCE, Alan
BOYCE, Keith Mossetta, B.E.
BRADING, Rowland William
BRADLEY, Russell Terence
BREND, Colin James
BREWER, Norman Lynton, B.E.
BRISKHAM, Harold Raymond
BRUNSKILL, Raymond Harborough
BUMFORD, Brian Arthur
BUNNER, Alfred George
BURGESS, David Cyril
BURKE, Frederick Charles

Graduates (contd.)

CARSON, William
CIPOLLINA, Giuseppe, DR.ING.
COFFEE, Ronald Alan
COMBER, Gerald
COOPER, Alan William
COUCHY, Brian Emile
COWEN, Maurice
COX, Maurice Edward
CRAWCOUR, Richard Hutton
CRESSWELL, Peter
CUSHING, Brian Michael
DAGNAN, John Cyril
DAY, David Kenneth
DAY, John
DERBYSHIRE, Robert Heyworth
DIAS, Douglas Bruce
DIBBEN, Leslie Charles
DONEGAN, James
DUNKLEY, Sydney Edward
EADES, Colin George
EDWARDS, Peter Kenneth
EDWARDS, Stephen Albert
ELESO, Mobolaji Adebayo
EMERY, Anthony George Montague
EVANS, Thomas Alwyn
FELL, Stuart John
FORREST, Eric Graham
FORREST, Sidney Arthur Edward
FORSTER, Peter Derek
FURNISS, Clifton
GARDNER, Anthony Trevor
GARRAWAY, Dan
GLEAVE, James Ernest
GOODHAND, David
GOODWIN, Dennis Sydney, B.SC.(ENG.)
GRAY, Jack Frederick Allen
GREEN, Harry Horton
GREGORY, George Henry
GRIFFITH, Donald
GRONOW, Peter John David
HALL, Raymond
HALL, Ronald George
HALLAM, Derek
HARRIS, Kenneth Jack
HARRISON, Leslie
HASSALL, Douglas Charles
HAWKINS, William James
HAY, James Patrick
HAYDEN, Robin John
HAYWARD, Brian Philip
HEATON, Malcolm William
HENDERSON, James David Clive
HICKS, Anthony Gilbert
HIGGINS, Keith George
HILL, Richard Maxwell, B.A.
HOLDSWORTH, Robert
HORNER, John Joseph
HOUGH, Roy
HOWARTH, Eric
HOWE, Kenneth George
HUGHES, Ioan Telford, B.SC.
HUTCHINGS, Keith Leonard
HUTCHINSON, Ralph
HYNAM, Peter John
IZZARD, Alan
JACKMAN, Peter John
JACKSON, Derek Ronald
JAFFE, Bernard William, B.A.
JAMES, John Malcolm
JAMES, Peter Bernard, B.SC.(ENG.)
JARDINE, David Graham
JELLEY, Edward Horace
JONES, David Hefin
JONES, Gordon Richard
KAVANAGH, Robert John, B.SC., M.A.SC., PH.D.
KENDALL, Desmond James
KHAN, Abdul Salamat
KILBY, Cyril Ivor
KILLORAN, Brian
KING, Anthony Henry
KING, Donald Clifford
KING, Peter George
KITSON, Roy
KOSLOWSKY, Vasyl
LAKE, John Leonard
LEAVITT, Frederick Clarence
LELLIOTT, Roy
LINAKER, Roy
LOCKETT, Thomas Alfred
LORD, John
LOWES, Peter
LUTHER, Stuart Frank, B.SC.
LYNCH, Eugene Bernard
LYNCH, Richard Dennis
LYNE, Arthur Edward
MCCARTHY, James Patrick
MARLOW, Ramon
MASON, Arthur Charles
MATEAR, William Crawford
MATHER, Raymond Arthur
MATTHEWS, Graham Farrah
MILES, Thomas Dennis
MILLER, Norman Howard
MILLER, Rodney William, B.SC.(ENG.)
MITCHELL, William Gault
MORGAN, Charles Thomas
MOSSOP, Joseph
MYCOCK, Brian Leslie
NEWEY, Vernon Roy
NISBET, Robert Wood
NUTT, Elwyn George
O'GRADY, Arthur Joseph, B.E.
OLIVER, Allan
OSBORNE, George James
OYELEYE, James Olateju, B.SC.(ENG.)
PARKER, John Denis Anthony
PARKER, Richard Howard, B.SC.
PARKES, George Robert
PATRICK, Peter
PEREIRA, William Vivian
PHILLIPS, Peter Gwyther
PHOENIX, Lancelot
PICKFORD, Stanley George
PITCHER, Stanley
PLANT, Norman John
POWELL, Robin Hugh
PRICE, David Griffiths
PRICE, Geoffrey William George
PUCKNELL, Douglas Albert
PURCHASE, John
PURSEHOUSE, James Peter
RAJASINGAM, Rajah Gabriel
READ, Michael Batham
REDHEAD, Ralph Kenneth
RENSHAW, Donald Wilfred
RICHARDS, Kenneth Harold,
RINGROSE, Keith Hugh
RISHTON, Donald Kay
RIXOM, Peter Barrie, B.ENG.
ROBERTS, Brian John
SALTER, Stuart Lewin
SAMUEL, Morton Augustus, B.SC.
SATTAR, Abdul
SENIOR, John
SHARMA, Amrit Lal
SHILLING, Harry Edwin, M.SC.
SIDDALL, Harry Beach
SIMMONS, Sidney
SMITH, Derrick Alfred
SMITH, James Hurst
SMITH, John Kenneth
SMITH, Peter Charles Martin
SOUTER, Jack Brockhurst
SPAIN, David Anthony
STANLEY, David
STANLEY, Michael Colston, M.A.
STATT, Stanley
STODDART, Brian Godfrey
STRATTON, Alexander
STYLES, Donald
SWINNERTON, Gordon Noel Thomas
TATE, Alan
TAYLOR, Alan Thomas
TAYLOR, Colin
TERRY, James Ernest
THOMAS, Desmond Henry
THOMAS, Gwilym Henry
THOMASON, Benjamin
THORLEY, Victor Gilbert
THORY, Ronald Gordon
TILLOTSON, Vincent Leonard
TONEY, Howard
TONGE, Kenneth
TWINE, John Edward
USHERWOOD, Michael James Douglas
VESEY, Robert
WADDON, Edwin John
WALDEGRAVE, Anthony John
WALLACE, John

Graduates (contd.)

WALTERS, George
WARRINGTON, Richard Arthur Lewis
WEARNE, George Wilfrid
WEBB, Roger John, B.SC.(ENG.)
WEST, Gerald Stanley
WHITE, Bryan Sydney
WILKIE, Brian Roger
WILKINSON, John Albert
WILLIAMS, Edward William
WILLIAMS, Lewis
WILSON, Frederick James
WILSON, James Alan
WILSON, Sgt. James Ramsay
WILSON, William
WOLLASTON, Terence Cornthwaite, B.
WOODWARD, David Carver
YATES, Lee

Students

AGARWAL, Jawahar Lal, B.SC.
AKED, Anthony
ARUMUGAM, Thirumugam Vignarajah
ASHWORTH, David George
BABU, Vadivale, B.E.
BANKS, John Edward
BENJAMIN, Donald Julian
BHATTACHARYYA, Charu Krishna
BOSE, Subimal, B.SC.
BOSTOCK, Edward Roy
BRADBURN, Donald Gordon
BRAMLEY, David Frederick
BRION, Stanley Albert
BROWN, David John
BROWN, John Thomas
BULLEN, Nigel
BURNS, William
CAMPBELL, John
CAMPBELL, John Malcolm, B.SC.
CARTER, Kenneth Blackburn
CARTWRIGHT, Derek John
COWLEY, Christopher Vincent
CRITCHLEY, Arthur Walter
CRYER, Terence Frederick
CURRIE, William John Murdoch
DAMERAL, Thomas Charles
DARNEY, Ian Brook
DAVIES, Cyril Havard
DAVIS, Ronald William
DAY, Raymond Harvey
DORE, Derek Frederick George
EDWARDS, David George
EUNSON, Eric Magnus
EWING, Ernest Frederick
FERGUSON, John Alexander
GANDERTON, William
GARDINER, Derek John
GREEN, John Owen
GROVE, Roger Michael
HAIR, Hugh Archer
HAMILTON, Graham Archibald
HAQUE, Shah Mobinul, B.SC.
HARI, Govindbhai
HARRIS, Alan Francis William
HARRIS, Graham Toyne
HATTON, James William
HENTLEY, Edward Leonard
HEWITSON, Thomas Alastair
HOLLAND, Derek Albert
HOLMES, Miss Jeannine Mary Lesley, B.SC.
HORSNELL, Arthur Christopher
HOSKIN, Brian John
HUGHES, Brian Patrick
JAMES, William Alexander
JONES, William Gwyn Rees
KANADE, Vasant Mukund
KAR, Supriya, B.SC.
KAY, John McLaren
KECHARANANTA, Pranote
KEEFE, Brian Edward
KERR, George
KERSH, Claude
LARNACH, Eric
LAWRENCE, Peter John
LEONOWICZ, Jan
MACKERTICH, Paul John
MCLEAN, Graham Wilson
MALLALIEU, John Patrick
MILES, Clifford Victor Harry, B.SC.
MOWAT, James, M.A.
MUKHERJEE, Balaichand, B.SC.
MUKHERJI, Archi Deb, B.SC.
MUTHURAJAH, Nadarajah
NEWTON, David Arthur
NUTT, Peter Charles
OPOKU, Nicholas Kobina
PACE, George Graham
PASMORE, Tom, B.SC.
PAUL, Ian Andrew
REEKIE, Alan Fraser
REEVE, Ivor Lionel
RIZVI, Saiyid Ali Mustahsan, B.SC.(ENG.)
ROGER[illegible]k Douglas
SAINI [illegible]der Singh
SAN[illegible]ARAM, Joseph
SHARDA, Baboolal, M.SC.
SHEPHARD, James Henry, B.SC.(ENG.)
SHEPHERD, Peter
SIMPSON, Anthony
SMITH, Ian McKenzie
SMITH, Michael Henry Arnould
SPARROW, John Osborne
STRINGER, Peter Edwin
THALGODAPITIYA, Ananda
THOMAS, Gordon Keith
THROWER, Charles George
TOWNSEND, Brian Joseph
TRITT, Barry Howard
TURNER, Malcolm
VERMA, Rabindra Nath
WILDRIDGE, Ernest Robert
WINGATE, Kenneth
WOOD, John Michael Steer

TRANSFERS

Student to Graduate

AHMED, Sqd.-Ldr. Khwaja Mohiuddin, B.SC.(ENG.), P.A.F.
AINGE, Robert James
ARMSTRONG, John Stanley, B.SC.
ASLING, John
ATKIN, Graham
BACON, Kenneth Frank
BAILEY, Kenneth
BAKER, Michael Charles
BANNOCK, Keith
BARCHAM, Henry Pattle, B.E.
BARKER, Victor Allan, B.ENG.
BATE, Daniel George, B.SC.(ENG.)
BEARDSMORE, William
BORKETT, John, B.SC.
BRADLEY, Henry Knight
BROWN, John Reginald Dawkins
BROWN, Norman John
BURNLEY, Leslie
CALLARD, David Royston
CANDY, Michael St. John, B.SC.(ENG.)
CARHART, Jack Charles Richard
CARRUTHERS, John George William, B.SC.
CARTWRIGHT, Jeffrey
CHALLENGER, Michael Trevor
CHAMBERS, John Ernest
CHANDRA, Akhileshwari Narain, B.SC.
CLARK, Frederick John Augustus
CLAYTON, Barrie, B.ENG.
COOK, Donald Edward George
CRAVEN, Peter Gordon
DENNIS, Graham
DEWSON, Robert William, B.SC.
DILWORTH, Anthony John Nicholas, B.SC.TECH.
DOBBY, Raymond
DOWNES, William
DUBBER, Thomas Albert
DWEK, Maurice Gabriel, B.SC.(ENG.)

Student to Graduate (contd.)

EARL, Neville Colin
EMMERSON, Bruce William
FARNWORTH, George Harold
FERENCZY, Gabriel Imre
FITZGERALD, Michael William
FOX, Norman
FREEMAN, Brian Vincent
FULLER, Brian Walter, B.SC.(ENG.)
GAGE, David Francis, B.SC.(ENG.)
GAUDEN, Clarence Godfrey, B.SC.(ENG.)
GEE, Norman
GOLSBY, Robin James
GOOSEY, Norman Frederick
GREGSON, Norman
GREY, Donald James
GRIFFIN, Eric James, B.SC.(ENG.)
HAGUE, Gordon Derek
HALSALL, Eric
HARGRAVE, James Brian
HARTLEY, Eric.
HATHAWAY, Andrew William
HAWKINS, David George
HAWORTH, Richard Anthony
HEALD, Derek Michael, B.SC.(ENG.)
HEATH, Norman Arthur Kenneth
HENNAN, Errol Hamilton
HENWOOD, David John
HOARE, Ernest
HOPKINS, David
HUDDART, Jack Edward
HUNT, Roland Walter Benjamin
ILES, Graham Cedric
ILIFFE, David William
JEBSON, Philip, B.SC.
JOB, John Henry
KELSEY, Ronald Arthur
KINGSLEY, James Herbert
LAMBERT, Walter Oliver
LANG, Brian John, B.SC.(ENG.)
LANGFORD, John Alastair
LARSSEN, Bjørn
LATHAM, Francis Gerard
LEONG, Kwok Onn, B.SC.(ENG.)
LINES, Denis
LOGUE, Hugh
LORD, Geoffrey Harold
MANGLA, Harish Chandra, B.SC.
MARCH, Barry Desmond Roy

Student to Graduate (contd.)

MASON, Guy
MATTHEWS, Thomas Graham
MILES, Frank Alexander
MORAN, Thomas Alfred
MORLING, Kenneth Frank
MUTHYAH, Susai Raj, B.A., B.SC.(ENG.)
NELSON, Brian
OLORUNSHOLA, Samuel Ademola
PARKER, John Martin
PARKINS, Edward George
PARSLOW, Brian George Stephen
PEACHEY, Ronald Ernest
PELLS, Brian Albert
PICKERING, Trevor, B.ENG.
PORTER, Henry
PORTER, John Michael
PRICE, Robert Edward
PULLIN, Instr. Sub.-Lt. Michael, R.N.
ROTH, Lewis George
RYAN, William Joseph, B.E.
SAALER, Peter Terence, B.SC.(ENG.)
SAUNDERS, Michael William
SIDDIQI, Khurshaid Ahmad, B.SC.(ENG.)
SIMPSON, Eric Ernest
SMITH, John Alfred
SMITH, Vernon Robert
SUMNER, Patrick James Coleridge
TENNANT, David
THAWANI, Ghanshyam Vensi, B.SC.
THOMSON, Alexander, B.SC.
THORNE, Brian Leslie
TRACY, Peter Addis, B.SC.
WALDRON, Colin
WALLACE, Gordon Richard
WARDILL, David Henry
WARFORD, Stuart Harold
WATSON, Brian Theodore
WHITE, Kenneth Stuart
WHITING, George Benjamin
WIDNALL, Michael Kevin
WILSON, Godfrey James
WILSON, Jack
WINSHIP, Colin
WOLFENDEN, Brian Arthur
WOOD, Richard Argent, B.ENG.
WRAY, Arthur Henry
WYATT, Capt. Michael John, B.SC.(ENG.), R.E.M.E.

Denotes that the publication is also in the Lending Library. The publications cannot be bought through The Institution; the publishers and the prices are given only for the convenience of members.

BOOKS

BARKER, M. L. 413 = 30

Basic German for Science Students with Vocabulary and English Translations of the German Passages. 5th ed.*

London, Oliver and Boyd, 1956. pp. x, 164. 22 × 15 cm. 12s. 6d.

Designed for those science students who wish to gain a reading knowledge of the German language. The first part contains a short introduction to the basic grammar, which is followed by extracts of a general nature for translation. The second part of the book is confined to short extracts on a wide range of scientific subjects including physics, mathematics, and chemistry. In both parts there is an English key to the passages on the opposite page. There is an extensive vocabulary.

BISHOP, D. O. 37

Electrical Engineering Electric Power, Telecommunications and Electronics*

London, Hale, 1957. pp. 107. 19 × 13 cm. 8s. 6d.

Gives a brief survey of the many subjects covered by electrical engineering; describes the different types of job available—craftsmen, technicians and professional electrical engineers—and the degree of skill and education and training required for each. The educational facilities in this country for students are described.

BITTEL, L. R., MELDEN, M. G., and RICE, R. S. 658.2

Practical Automation Methods for Increasing Plant Productivity

London, McGraw-Hill, 1957. pp. vii, 376. £2 16s. 6d.

This book is perhaps best described as a pictorial description of automation in action. The examples illustrated serve to show how widely industry in the United States is making use of controlled and automatic handling for assembly lines.

CHERRY, C. 621.391

On Human Communication. A Review, a Survey and a Criticism*

New York, Technology Press of Massachusetts Institute of Technology and Wiley, 1957. pp. xiv, 333. 23 × 15 cm. £2 14s.

This is intended as an elementary review of the subject, and is not for the expert, but for the general reader. It consists of a series of essays on communication, signs, language, etc., the analysis of signals especially speech, and statistical theory and logic applied to communication.

LIBRARY ACCESSIONS

CHURCHMAN, C. W., ACKOFF, R. L., and ARNOFF, E. L. 65

Introduction to Operations Research*

London, Chapman and Hall, 1957. pp. x, 645. 23·5 × 15 cm. £4 16s.

This book, intended as an introduction to the subject, explains what is meant by operational research. It explains the way to analyse an organization and formulate the problem with the aid of models and diagrams and the simple mathematics involved. Examples are given and solved and the chapters end either with a summary or conclusion and a bibliography.

COOKE-YARBOROUGH, E. H. 621.314.7

An Introduction to Transistor Circuits*

Edinburgh, Oliver and Boyd, 1957. pp. 154. 23 × 15 cm. 15s.

This book is concerned mainly with the non-linear properties of transistors; hence transistor circuit noise, power amplifiers, tuned amplifiers and radio receiver circuits are not considered. The main part of the book deals with pulse circuits, but scaling circuits, switching, computer and other applications are discussed. The book was reviewed in the December 1957 issue.

CULLWICK, E. G. 538.3

Electromagnetism and Relativity with Particular Reference to Moving Media and Electromagnetic Induction*

London, Longmans, Green, 1957. pp. xxiii, 299. 22 × 14 cm. £3 3s.

This is an advanced book concerned with moving bodies and electromagnetic induction. It gives a detailed explanation of the Special Theory of Relativity and its application to electromagnetism, and also an original elementary theory which is applied to various classical experiments. The book will be reviewed in a future issue.

DALES, J. H. 93 : 621.311

Hydroelectricity and Industrial Development Quebec 1898–1940

Cambridge, Mass., Harvard University Press, 1957. pp. xii, 269. 24 × 16 cm. £2 5s.

This serious work, based on a research project, is an historical account of the development of the main Quebec power companies. It describes in detail how the large initial capital outlays were invariably financed from private funds, and how industrial development has been influenced by the availability of hydroelectric power.

EFRON, A. 53

Basic Physics Vols. I and II

New York, Rider, 1957. pp. xii, 692. 24 × 17 cm. $7.60.

This work covers the whole field of physics. It is copiously illustrated with pictures and pictorial diagrams and is intended for high-school classwork. Magnetism, electromagnetism, electrostatics and electrochemistry are dealt with. A considerable part of the book is allocated to the subject of electricity including an introduction to radio.

FLÜGGE, S. (Editor) 53

Handbuch der Physik Band XXVIII Spektroskopie II. (Encyclopedia of Physics, Vol. 28. Spectroscopy II)

Berlin, Springer, 1957. pp. vi, 448. 25 × 17 cm. £6 14s.

This further volume in the series contains five chapters, two in English —on microwave spectroscopy and the Zeeman effect, two in German—on continuous spectra and crystal spectra, and one in French—on rotary polarization.

FOURMAN, M. 413 = 82

Science Russian Course*

London, University Tutorial Press, 1949. pp. viii, 274. 19 × 12 cm. 11s. 6d.

This book is designed for those who wish to read scientific Russian, but who have no previous knowledge of the language. A brief survey of the grammar is followed by a number of passages for translation taken from scientific books and periodicals, covering a wide range of subjects mainly in the fields of physics, chemistry and the natural sciences. There is an extensive vocabulary.

GINZTON, E. L. 621.317.029.6

Microwave Measurements*

London, McGraw-Hill, 1957. pp. xvii, 515. 24 × 16 cm. £4 10s.

Intended to cover the basic forms of measurement in the microwave region. It deals with laboratory generation, detection and measurement of microwave power, discusses impedance concepts and measurement of microwave frequencies, including wavelength, frequency, Q and R_0/Q_0.

GOODMAN, L. L. 658.2

Man and Automation*

Harmondsworth, Penguin, 1957. pp. 286. 18 × 11 cm. 3s. 6d.

The first part of this book reviews the development of automation, giving descriptions of some recent applications in industry and commerce. Then the social and economic problems associated with automation are reviewed; in this connection the author deals with the attitude of the trade unions and management, and the need for more technological education. This book was reviewed in the October 1957 issue.

HARBOTTLE, H. R., and HANMAN, B. L. G. 621.39

The Principles of Telecommunications Engineering Vol. 1*

London, English Universities Press, 1957. pp. xii, 373. 21 × 14 cm. 17s. 6d.

This is the first of three volumes and is intended to cover the first year syllabus of the City and Guilds Institute's curriculum in Telecommunication Principles. The subsequent volumes will cover the second and third year courses. It includes many worked examples and problems to be answered from previous examination papers. The M.K.S. system is dealt with in an appendix.

KING, G. J. 621.396.619

F.M. Radio Servicing Handbook

London, Odhams, 1957. pp. 192. 23 × 15 cm. 25s.

A practical guide to frequency-modulated v.h.f. radio receivers; their design, construction, alignment and repairs; with chapters on adaptors, aerials and high-fidelity audio equipment.

KING, R. W. P. 621.396.

The Theory of Linear Antennas with Charts and Tables for Practi Applications*

Cambridge, Mass., Harvard University Press, 1956. pp. xxi, 9 26 × 17 cm. £8.

A systematic and comprehensive survey of linear antennas includ circuit and field properties. Both theoretical and experimental aspe of the subject are treated, and special care has been taken to correl theory with experiment. Extensive tables, charts and curves included.

KITTEL, C. 539.

Introduction to Solid State Physics. 2nd ed.*

London, Chapman and Hall, 1956. pp xv, 617. 23 × 15 c £4 16s.

A certain standard in physics is expected of the reader, for examp familiarity with the Planck radiation law, the de Broglie relation a the Zeeman effect; and a background of quantum mechanics wou be helpful. Amongst the subjects dealt with are dielectric propert ferroelectric crystals, diamagnetism and paramagnetism, se conductors, ferromagnetism, superconductivity, and photoconductiv

KNOWLTON, A. E. (Editor-in-Chief) 621.31 (0

Standard Handbook for Electrical Engineers. Prepared by a staff Specialists. 9th ed.

London, McGraw-Hill, 1957. pp. xi, 2230. 23 × 16 cm. £6

Revisions to take account of changes in units and in standards a new developments since the previous edition was published in 19 have been made. Otherwise this well-known work has not be altered, and it retains the same style and coverage.

KOZMETSKY, G., and KIRCHER, P. 518.

Electronic Computers and Management Control*

London, McGraw-Hill, 1956. pp. vii, 296. 24 × 15 cm. £1 17s. 6

This is a book for management personnel. It describes in non-technic terms the various types of electronic computer equipment, includ input and storage devices, how they work and their applications business.

LEDERER, M. 537.3

An Introduction to Paper Electrophoresis and Related Metho 2nd Impression with Minor Additions

London, Elsevier, 1957. pp. x, 213. 23 × 15 cm. £1 17s. 6d.

This is one of the few books on this very specialized subject and is limited interest. It is nevertheless an important reference wor containing many bibliographical references to the literature of t subject.

LINCOLNE, G. B. 93 : 621.3

History of the Electric Light and Power Industry in Victoria

Published privately in Victoria by the Author, 1957. pp. 30 33·5 × 21 cm.

Covers a period of approximately 90 years, reviewing very ea developments, expansion in the Melbourne city area, the Met politan area and later the State of Victoria. It is an interesti account of engineering and commercial progress and although figur are extensively quoted it is a very readable story.

LLOYD'S REGISTER OF SHIPPING 629.1

Rules and Regulations for the Construction and Classification Steel Ships

London, Lloyd's Register, 1957. pp. 535. 29 × 25 cm.

Includes construction rules for electric propelling machinery and f electrical equipment.

MAYERS, M. A., and CHIPP, R. D. 621.397.9

Closed Circuit TV System Planning

New York, Rider, 1957. pp. xii, 250. 27 × 21 cm. £4.

Part I illustrates applications, Part II describes how closed-circuit television, including colour television, works, and Part III describes equipment. The book is extensively illustrated with photographs and diagrams.

MOLLOY, E. (Editor) 621.31 (03)

Newnes Electrical Pocket Book. 14th ed.

London, Newnes, 1957. pp. viii, 384. 17 × 10 cm. 10s. 6d.

This edition contains a section dealing with the 13th edition of the Regulations for the Electrical Equipment of Buildings.

MORLEY, B. L. 621.396.82

Suppressing Radio and Television Interference*

London, Norman Price, 1956. pp. 64. 22 × 14 cm. 5s.

Describes the causes of interference, the basic principles of suppression, and practical steps to locate and suppress the interference. Various types of television interference are illustrated.

MURPHY, G. J. 621–52

Basic Automatic Control Theory

London, Van Nostrand, 1957. pp. xi, 557. 23 × 15 cm. £3 7s. 6d.

Describes the analysis and synthesis of linear control systems having only fixed, lumped parameters, and subject to input commands and disturbances which can be specified. Definitions of terms and the characteristics of common control-system components are followed by chapters on the Laplace transform, the transfer-function concept and signal flow diagrams. Stability, frequency response, time response and the use of the analogue computer are considered.

NIKOLA TESLA MUSEUM 081 (TES)

Nikola Tesla Lectures, Patents, Articles

Belgrade, Nikola Tesla Museum, 1956. pp. xx, 802. 28 × 20 cm.

A volume to commemorate the centenary of the birth of Nikola Tesla, consisting of reprints of his lectures and articles and copies of the United States Patents bearing his name. The final article is an autobiography originally published in 1915.

NOAKES, G. R. 53

New Intermediate Physics

London, Macmillan, 1957. pp. viii, 961. 22 × 14 cm. 30s.

This work is based on the author's four previously published textbooks on light, heat, electricity and magnetism, and general physics. A chapter has been added on acoustics, and much of the work on light and on electricity has been rewritten. The treatment of electricity is modern, and the M.K.S. system of units is used.

PANOFSKY, W. K. H., and PHILLIPS, M. 537

Classical Electricity and Magnetism

Reading, Mass., Addison-Wesley, 1955. pp. xi, 400. 23 × 16 cm. £3 8s.

This is not an elementary book. The emphasis is on physical theory as evolved from fundamental empirical laws rather than on mathematics and strict internal logic. Nevertheless, the reader is assumed to be familiar with advanced calculus, differential equations and vector analysis and, for the later chapters, with classical mechanics to graduate level.

PATCHETT, G. N. 621.397.62

Television Synchronizing Separators*

London, Norman Price, 1957. pp. 71. 22 × 14 cm. 5s.

Discusses first the principle of synchronizing; then describes a number of circuits from the simplest to the complex circuits designed to give satisfactory interlace. Fly-wheel synchronizing circuits are dealt with in the final chapter.

PENNING, F. M. 537.52

Electrical Discharges in Gases*

London, Cleaver-Hume, 1957. pp. viii, 78. 23 × 15 cm. 15s.

This work was originally published in Dutch in 1955. An introduction to the subject is followed by chapters on the movement of electrons and ions through a gas, the self-sustaining and non self-sustaining arc discharge, the Townsend discharge, sparks and lightning, the glow discharge, and the positive column.

PFLEIDERER, C. 621

Strömungsmaschinen 2te Aufl. (Turbo-machinery. 2nd ed.)

Berlin, Springer, 1957. pp. xii, 421. 24 × 16 cm. £3.

This is a detailed treatment of the theory and the mechanical features of gas and liquid turbomachinery, including steam turbines, centrifugal compressors and pumps.

RADIO RESEARCH LABORATORIES, MINISTRY OF POSTAL SERVICES, TOKYO 621.396.11

Atlas of Radio Wave Propagation Curves for Frequencies Between 30 and 10 000 Mc/s

Tokyo, Ministry of Postal Services, 1957. pp. 244. 30 × 21 cm.

Standard propagation diagrams in the standard atmosphere, the interference region, the diffraction region, behind mountains, and in the scattering region.

ROLF, E. 621.314.62

Der Kontaktumformer (Contact Rectifiers)

Berlin, Springer, 1957. pp. ix, 549. 25 × 17 cm. £6 15s.

Both the theoretical and engineering aspects of mechanical rectifiers are treated, with particular reference to Continental equipments. Design, constructional details, protection, testing and commissioning are described, and there is a bibliography.

RYDER, J. D. 621.385

Engineering Electronics with Industrial Applications and Control

London, McGraw-Hill, 1957. pp. x, 666. 24 × 16 cm. £3 12s.

Specifically excludes the radio field. A general introduction and a lengthy consideration of amplifiers are followed by descriptions of the principles and basic circuits involved in applications of electronics in computers, oscillators for h.f. heating, welding control, servo-mechanisms and many other industrial developments.

SCHUISKY, W. 621.313.3

Induktionsmaschinen (Induction Machines)

Vienna, Springer, 1957. pp. xii, 501. 25 × 17 cm. £7 11s. 6d.

A comprehensive study in which the necessary theoretical matter is accompanied by practical information. For example, there are useful sections on special applications of induction machines, on testing and on German standards, also two chapters on design procedure, with specimens, a full glossary of symbols used, and a modern bibliography. The book will be reviewed in a future issue.

SOUTH AFRICAN INSTITUTE OF ELECTRICAL ENGINEERS 621.315.3

Standard Regulations for the Wiring of Premises. 2nd ed. amended

Johannesburg, South African Institute of Electrical Engineers, 1955. pp. vi, 200. 18 × 12 cm. 6s. 6d.

STARR, A. T. 621.31

Applied Electricity*

London, Pitman, 1957. pp. x, 502. 22 × 14 cm. 25s.

Covers the syllabus of Applied Electricity for Part I of the B.Sc.(Eng.) degree of London University and also that for the Higher National Certificate. The M.K.S. system of units is used throughout the text.

STARR, A. T. 621.39 (03)

Radio and Television Engineering. 4th ed.

London, Pitman, 1957. pp. vi, 66. 14 × 11 cm. 2s.

This small pocket book gives definitions for a number of terms and brief explanation, formulae and circuits, concerning L, C, R, Z, resonance and coupled circuits.

STEPHENS, R. C., and WARD, J. J. 531

Applied Mechanics

London, Cleaver-Hume, 1957. pp. xi. 19 × 13 cm. 12s. 6d.

Intended for students preparing for the third year of the Ordinary National Certificate course in Mechanical Engineering.

WATSON, G. O. 629.12 : 621.3

Marine Electrical Practice*

London, Newnes, 1957. pp. viii, 325. 22 × 14 cm. £1 15s.

This book is not intended for experienced electrical engineers but for sea-going engineers and others studying for Ministry of Transport Examinations who are likely to have charge of electrical installations in a ship. It deals with generators, motors and their control, with batteries, lighting, cables and distribution, with electrically driven auxiliaries, and with electrical testing, and there are many illustrations and diagrams.

WHITROW, M. (Editor) 014:043

Index to Theses accepted for Higher Degrees in the Universities of Great Britain and Ireland. Vol. IV. 1953–54

London, Aslib, 1956. pp. xii, 158. 24 × 15 cm. 25s.

WITTS, A. T. 621.396.62

Radio Upkeep and Repairs. A Practical Handbook on Servicing Principles and Receiver Maintenance. 8th ed.

London, Pitman, 1957. pp. v, 234. 19 × 12 cm. 15s.

This edition contains new chapters on servicing f.m. receivers, transistor circuits, and printed circuits.

OTHER PUBLICATIONS

ACTON SOCIETY TRUST

Size and Morale Part I. A Preliminary Study of Attendance at Work in Large and Small Units

London, Acton Society Trust, 1953. pp. 44. 22 × 14 cm. 3s. 6d.

Size and Morale Part II. A Further Study of Attendance at Work in Large and Small Units

London, Acton Society Trust, 1957. pp. 36. 22 × 14 cm. 3s. 6d.

ASSOCIATION FOR APPLIED SOLAR ENERGY

Proceedings of the 1957 Solar Furnace Symposium

Phoenix, Arizona, Association for Applied Solar Energy, 1957. pp. 116. 27 × 21 cm. £2.

ASSOCIAZIONE ELETTROTECNICA ITALIANA

Rendiconti della 57th Riunione Annuale dell'A.E.I., Trieste, 1956. Regolazione Automatica e Servomeccanismi. Fascicolo I and II

Milan, A.E.I., 1957. pp. 101, 456. 30 × 21 cm.

B.B.C. ENGINEERING DIVISION

The B.B.C. Riverside Television Studios: The Architectural Aspects

London, B.B.C. Engineering Division, Monograph No. 13, 1957. pp. 25. 28 × 22 cm. 5s.

CENTRAL ELECTRICITY AUTHORITY

The 275 kV System of the Central Electricity Authority in the United Kingdom. Based on a paper by F. J. Lane, presented before the 19th Annual Meeting of the American Power Conference, Chicago, March 27th–29th, 195/

London, C.E.A., 1957. pp. 28. 22 × 14 cm.

DENZER, H. W.

Die Elektrofischerei (Fishing by Electricity)

Stuttgart, Nägele u. Obermiller, 1956. pp. 92. 26 × 18 cm. £2 13s. 9d.

FIRE PROTECTION ASSOCIATION

Space Heating

London, Fire Protection Association, 1957. pp. 16. 22 × 14 cm

Electricity and the Fire Risk in Industrial and Commercial Premis

London, Fire Protection Association, 1957. pp. 32. 22 × 14 cm

GENERAL ELECTRIC COMPANY LIMITED

The Transistor. Its Development. Its Application. Its Advantag How it Works

London, G.E.C., 1957. pp. 15. 25 × 19 cm.

HEINRICH, R. F., and ANDERSON, J. R.

Electroprecipitation. A Reprint from Chemical Engineering Practic Vol. 3

London, Butterworth, 1957. pp. 50. 25 × 15 cm.

INSTITUTE OF COST AND WORKS ACCOUNTANTS AN BRITISH PRODUCTIVITY COUNCIL

Costing Matters. Wages, Machines, Materials, Overheads, Budg tary Control, and Standard Costing

London, Institute of Cost and Works Accountants and Briti Productivity Council, 1957. pp. 48. 21 × 14 cm. 2s. 6d.

KRZHIZHANOVSKY, G., and VEITS, V.

A Single Power Grid for the U.S.S.R.

Moscow, Foreign Languages Publishing House, 1957. pp. 6 20 × 13 cm.

MARKIN, A.

Soviet Electric Power Developments and Prospects

Moscow, Foreign Languages Publishing House, 1956. pp. 13 20 × 13 cm.

MAY, K. L.

Preservation, Inspection and Maintenance of Transmission Pol Reprinted from the Record of the 1956 Annual Convention of t British Wood Preserving Association

London, British Wood Preserving Association, 1956. pp. 1 24 × 15 cm.

ORGANISATION FOR EUROPEAN ECONOMIC CO-OPERATION

Production Transmission and Distribution of Electricity in Europe

Paris, OEEC, 1957. pp. 93. 24 × 15 cm. 9s.

PEP (Political and Economic Planning)

Three Case Studies in Automation

London, Allen and Unwin, 1957. p. vi, 58. 24 × 15 cm. 7s. 6

PHYSICAL SOCIETY

Reports on Progress in Physics Vol. XX

London, Physical Society, 1957. pp. iv, 568. 25 × 17 cm. £3

UNITED NATIONS, ECONOMIC COMMISSION FOR EUROPE

The Mechanization in the Construction of Hydro Electric Pow Plants

Geneva, U.N., 1957. pp. vii, 52. 28 × 22 cm. 3s.

Forthcoming Events at Savoy Place

All meetings are held at Savoy Place, beginning at 5.30 p.m. (tea at 5 p.m.), except where otherwise stated. The nature of the meeting is indicated by the following key:

E EDUCATION DISCUSSION CIRCLE
I INFORMAL
M MEASUREMENT AND CONTROL SECTION
O ORDINARY
R RADIO AND TELECOMMUNICATION SECTION
S SUPPLY SECTION
U UTILIZATION SECTION

After each paper that has now been published is added the month that a synopsis has appeared in the *Journal* under 'Monographs and Papers published individually this month', i.e. about the time the paper has been published as a separate. A paper that has not yet been published will be available at least ten days before the meeting at which it will be read.

January 1958

M **21** *Tuesday* G. F. TAGG, PH.D., B.SC.(ENG.) Informal Lecture on 'The Effect of Modern Industrial Requirements on Electrical Instrument Design'†

R **22** *Wednesday* E. ESPING. Lecture on 'Special Problems of Broadcasting in Sweden'‡

R **27** *Monday* Informal Evening on 'An Inquiry into the Specification of Transistors', at which there will be a talk given by F. F. ROBERTS, B.SC.(ENG.)†

R **28** *Tuesday* Symposium of papers on 'Long-Distance Propagation above 30 Mc/s' (All those attending the Symposium are required to register. Full details and registration form obtainable from the Secretary.) See also p. 34

S **29** *Wednesday* J. L. DOUGLAS, B.SC.(ENG.) *and* A. W. STANNETT, B.SC.(ENG.) 'Laboratory and Field Tests on 132 kV Condenser Bushings' (Paper No. 2473 S) *Synopsis:* December 1957

February 1958

E **3** *Monday* Visit to Power Gallery of the Science Museum, South Kensington, S.W.7 (At 6.15 p.m., tea at 5.15 p.m.)

M **4** *Tuesday* (In conjunction with the British Nuclear Energy Conference) J. H. BOWEN, B.SC.(ENG.) *and* E. F. O. MASTERS, B.SC. 'Temperature Transients in Gas-Cooled Thermal Nuclear Reactors' (Paper No. 2422 M) *Synopsis:* October 1957

W. ABSON, B.SC., P. G. SALMON *and* S. PYRAH 'Boron-Trifluoride Proportional Counters' (Paper No. 2542 M) *and* 'The Design, Performance and Use of Fission Counters' (Paper No. 2546 M)

J. HOWLETT, B.SC., PH.D. 'The Application of Digital Computers to Nuclear-Reactor Design' (Paper No. 2507 M) *Synopsis:* see p. 33

S **5** *Wednesday* Section Dinner-Dance (At the Connaught Rooms, at 7 for 7.30 p.m.)

O **6** *Thursday* H. W. MELVILLE, D.SC., F.R.S. Kelvin Lecture on 'High Polymers'‡

I **10** *Monday* E. R. WILKINSON, C.M.G., will open a discussion on 'The Herbert Report and the 1957 Act'*

12 *Wednesday* G. H. FLETCHER, O.B.E. The Faraday Lecture: 'The Electrification of the British Railways'‡ (At the Central Hall, Westminster, S.W.1, at 6 p.m. Admission by ticket available on receipt of a stamped addressed envelope)

US **13** *Thursday* B. C. ROBINSON, PH.D., M.SC., *and* A. I. WINDER 'Supply-Voltage and Current Variations produced by a 60-ton 3-Phase Electric Arc Furnace' (Paper No. 2456 U) *Synopsis:* December 1957

M **18** *Tuesday* C. D. MEE, PH.D. 'Magnetic Tape for Data Recording' (Paper No. 2536 M) *Synopsis:* see p. 34 (To be read by J. F. Doust)

R **19** *Wednesday* L. C. JESTY, B.SC. 'The Relation between Picture Size, Viewing Distance and Picture Quality with special reference to Colour Television and to Spot-Wobble Techniques' (Paper No. 2540 R)

R **24** *Monday* Informal Evening on 'Stereophonic Recording on Gramophone Discs' at which there will be a talk given by H. A. M. Clark, B.SC.(ENG.)†

S **26** *Wednesday* P. RICHARDSON 'Design and Application of Large Solid-Rotor Asynchronous Generators' (Paper No. 2492 S) *Synopsis:* see p. 33

27 *Thursday* Annual Dinner (At Grosvenor House, Park Lane, W.1, at 7 for 7.30 p.m.)

March 1958

E **4** *Tuesday* K. R. STURLEY, PH.D., B.SC., will open a discussion on 'Some Impressions of Technical and Industrial Training in the United States'* (At 6 p.m., tea at 5.30 p.m.)

O **6** *Thursday* F. BUSEMANN, DR.ING., *and* W. CASSON 'Results of Full-Scale Stability Tests on the British 132 kV Grid System'

F. H. LAST, PH.D.(ENG.), B.SC.(ENG.), E. MILLS, *and* N. D. NORRIS 'The Organization for Large-Scale Grid System Tests' (Paper No. 2559)

I **10** *Monday* MISCHA BLACK, O.B.E., will open a discussion on 'The Industrial Designer—an Ally or Enemy of the Engineer?'*

M **11** *Tuesday* H. BLOMBERG, D.SC., *and* P. J. KARTTUNEN 'A Ferrometer for the Determination of the A.C. Magnetization Curve and the Losses of Small Ferromagnetic Sheet Samples' (Paper No. 2482 M) *Synopsis:* see p. 37 (To be read by Professor F. Brailsford, PH.D., B.SC.(ENG.))

J. MCFARLANE, B.SC., P. MILNE, *and* J. K. DARBY, B.SC.(ENG.) 'Direct-Reading Iron-Loss Testing Equipment for Single Sheets, Single Strips and Test Squares'

J. MCFARLANE, B.SC., *and* M. J. HARRIS, B.SC. 'The Control of Flux Waveforms in Iron Testing by the Application of Feedback Amplifier Techniques'

* No advance information will be available and no Press report will be permitted.
† An abstract will be available in advance.
‡ No advance information will be available.

British Nuclear Energy Conference: Forthcoming Programme

Forthcoming meetings of the British Nuclear Energy Conference are listed in the programme below. Unless otherwise stated, the following particulars hold for them: they take the form of the presentation and discussion of one or more papers; they are held at 5.30 p.m., with tea at 5 p.m.; and tickets of admission are not required.

JANUARY 21 *Tuesday*

SYMPOSIUM ON NUCLEAR ENERGY

Sponsoring society: The Institution of Chemical Engineers, 16 Belgrave Square, London, S.W.1.

Place of meeting: Hoare Memorial Hall, Church House, London, S.W.1. There will be two sessions, at 9.45 a.m. and at 2 p.m. Tickets of admission are required; those who have not previously registered will probably be able to do so at 9.30 a.m. on the 21st January, but the numbers attending the Symposium are limited to 500. Registration forms and further details are obtainable from The Secretary of The Institution of Chemical Engineers.

Morning Session

(*Chairman:* Sir John Cockcroft, O.M., K.C.B., C.B.E., F.R.S.)

9.45 Opening of the Symposium

9.50 *Presentation of the following papers:*

COMMISSIONING AND OPERATION OF 'A' STATION CALDER WORKS H. G. Davey, O.B.E., M.SC.

THE DEVELOPMENT OF THE BUTEX PROCESS FOR THE INDUSTRIAL SEPARATION OF PLUTONIUM FROM NUCLEAR REACTOR FUELS C. M. Nicholls, B.SC.(ENG.)

Morning Session (*contd.*)

10.50 FISSION PRODUCT DISPOSAL K. Saddington, M.SC.

11.10 Discussion

12.30 Lunch

Afternoon Session

(*Chairman:* Sir Hugh Beaver, K.B.E.)

2.00 A film entitled *Criticality*

2.20 *Presentation of the following papers:*

NUCLEAR CRITICALITY: A NOVEL FACTOR IN THE DEVELOPME OF PROCESSES, AND THE DESIGN AND OPERATION OF PLA C. M. Nicholls, B.SC.(ENG.), and A. H. C. P. Gillies B.SC., PH.D.

THE MARCOULE PLUTONIUM PLANT R. Galley

FUEL PROCESSING IN HOMOGENEOUS AQUEOUS REACT I. Wells, B.SC., D.I.C., and E. Lofthouse, M.SC., PH.D.

COMPUTATION OF THE PERFORMANCE OF A MULTI-COMPONE SOLVENT EXTRACTION SYSTEM: SEPARATION OF URANIUM A PLUTONIUM FROM FISSION PRODUCTS BY TRIBUTYL PHOSPH J. A. Williams, B.SC., and J. T. Wood, PH.D.

3.40 Tea

4.0 Discussion

5.20 End of Session

FEBRUARY 4 *Tuesday*

Sponsoring society and place of meeting: The Institution Electrical Engineers, Savoy Place, London, W.C.2.

A group of papers on

INSTRUMENTATION AND DESIGN PROBLEMS OF NUCLEAR REACTORS

See p. 45 for details.

Contents of the Current Issues of the *Proceedings*

The date in italics is that of the Journal review or special article. Where given, the date in small capitals refers to the month in which a paper was published individually.

PART A. POWER ENGINEERING (DECEMBER 1957)

See the Journal for December 1957, p. 662.

PART B. RADIO AND ELECTRONIC ENGINEERING (JANUARY 1958)

T. E. GOLDUP, C.B.E.
Inaugural Address *January 1958*

J. S. MCPETRIE, PH.D., D.SC.
Radio and Telecommunication Section: Chairman's Address *November 1957*
Centre and Sub-Centre Chairmen's Addresses

R. W. MEADOWS, B.SC.(ENG.). PAPER NO. 2427 R
The Attenuation of Radio Waves Reflected from the E-Region of the Ionosphere *December 1957*

R. W. MEADOWS, B.SC.(ENG.), AND A. J. G. MOORAT. PAPER NO. 2428 R
The Effect of Fading on the Accuracy of Measurement of Ionospheric Absorption *January 1958*

R. W. MEADOWS, B.SC.(ENG.), AND A. J. G. MOORAT. PAPER NO. 2429 R
The Effect of the Earth's Magnetic Field on Absorption for a Single-Hop Ionospheric Path *January 1958*

J. O. SPECTOR, PH.D. PAPER NO. 2430 R
An Investigation of Periodic Rod Structures for Yagi Aerials *October 1957*

F. J. HYDE, M.SC. PAPER NO. 2438 R
Some Measurements on Commercial Transistors and their Relati to Theory *Not yet reviewed*

PROFESSOR H. E. M. BARLOW, PH.D., B.SC.(ENG.), AND S. KATAOK PAPER NO. 2450 R
The Hall Effect and its Application to Power Measurement at 10 G *January 1958*

J. J. HILL, B.SC. PAPER NO. 2461 M
A Precision Thermo-Electric Wattmeter for Power and Audio Frequencies *January 1958*

P. N. ROBSON, B.A. PAPER NO. 2468 R
A Note on the Fourier Series Representation of the Dispersion Cur for Circular Iris-Loaded Waveguides *January 1958*

G. B. WALKER, M.A., PH.D., AND J. T. HYMAN, B.SC.(ENG.). PAP NO. 2480 R
The Use of Dielectric Materials to Enhance the Reflectivity of Surface at Microwave Frequencies *January 1958*

J. A. LANE, M.SC. PAPER NO. 2488 R
Transverse Film Bolometers for the Measurement of Power in Rectangular Waveguides *January 1958*

PART C. MONOGRAPHS (SEPTEMBER 1957)

See the Journal for September 1957, p. 525.

ANNOUNCEMENTS TO MEMBERS

THE HOMES FUND

SUMMARY OF CONTRIBUTIONS RECEIVED TO 20TH DECEMBER 1957

	No. of Contributors	£	*s.*	*d.*
£1 000 and over	6	6 000	0	0
£100 to <£1 000	30	6 586	3	0
£5 to <£100	839	8 959	17	1
£2 to <£5	2 023	5 530	7	11
Under £2	22 036	11 516	2	7
		£38 592	10	7

PROGRAMME OF MEETINGS

The programme card of London Meetings for the second half of the session is being sent with this issue to all members not residing within the area of a Local Centre or Sub-Centre.

Any member living in the provinces who often visits London, and is thus able to attend London Meetings, may obtain a copy of the card on application to the Secretary.

THE FARADAY LECTURE IN LONDON

The Faraday Lecture will be delivered by Mr. G. H. Fletcher,* O.B.E., MEMBER, at the Central Hall, Westminster, on Wednesday, 12th February, at 6 p.m., his subject being 'The Electrification of the British Railways'.

The primary object of the Faraday Lecture is to increase the interest of the general public in electrical matters, particularly those having an immediate bearing on the life of the community; **members are therefore requested to bring the Lecture to the notice of their friends.**

Admission is free, by ticket obtainable from the Secretary; members are requested to enclose a stamped addressed envelope with their applications.

APPOINTMENTS

WIRING REGULATIONS COMMITTEE: SUB-COMMITTEE NO. 7—CARAVAN INSTALLATIONS

On the nomination of the Air Ministry, the Council have appointed Mr. A. Benjamin, ASSOCIATE MEMBER, to serve on the above Sub-Committee in place of Mr. N. Holcroft, ASSOCIATE MEMBER

EXTRA-MURAL COMMITTEE ON THE APPLICATION OF ELECTRICITY TO INDUSTRIAL PROCESS HEATING

On the nomination of the Department of Scientific and Industrial Research, the Council have appointed Mr. R. Ashton, M.A., to serve on the above Committee in place of Mr. R. C. Silversides.

SUPPLY SECTION DINNER-DANCE

The annual Dinner-Dance of the Supply Section will be held in the Grand Hall at the Connaught Rooms, Great Queen Street, London, W.C.2, on Wednesday, 5th February, 1958, at 7 for 7.30 p.m. Application forms were enclosed to all members of the Section with last month's issue.

* At the time of going to press, news has been received of Mr. Fletcher's sudden death. Arrangements have been made for his Faraday Lecture to be given by Mr. R. Ledger, B.Sc.Tech., Associate Member.

MEMBERS TRAVELLING TO AND FROM THE UNITED KINGDOM

Members visiting or taking up residence in the areas of any of the Oversea Branches, Oversea Committees or Joint Oversea Groups, which are listed on pp. 65 and 66, are invited to apply to the Secretary of The Institution for a letter of introduction to the appropriate Honorary Secretary.

The Secretary will be obliged if members coming home from oversea will inform him of their addresses in this country, even if they do not desire a change of address to be recorded in the Institution register. This will enable him to advise such members of the various meetings, etc., of The Institution and its Local Centres, and, when occasion arises, to put them in touch with other members.

The Secretary will be pleased if those members from oversea who are able to visit the Institution premises will call upon him.

BRITISH CONFERENCE ON AUTOMATION AND COMPUTATION

CONSTITUTION OF GROUP B

Some particulars of the British Conference on Automation and Computation and its objects were given on p. 300 of the May 1957 issue of the *Journal*. On the 20th December 1957 Group B, known as 'The British Group for Computation and Automatic Control', was formally constituted, with the following societies as its members:

British Computer Society
Chartered Institute of Secretaries
Chemical Society
Faculty of Actuaries (Scotland)
Institute of Actuaries
Institute of Bankers
Institute of Chartered Accountants in England and Wales
Institute of Chartered Accountants in Scotland
Institute of Cost and Works Accountants
Institute of Fuel
Institute of Municipal Treasurers and Accountants (Incorporated)
Institute of Petroleum
Institute of Physics
Institution of Civil Engineers
Institution of Electrical Engineers
Institution of Mechanical Engineers
Institution of Production Engineers
Iron and Steel Institute
Office Management Association
Royal Aeronautical Society
Royal Institute of Public Administration
Royal Statistical Society
Society of Instrument Technology

The Group constitution provides for the election of additional member societies: those interested should communicate with the Honorary Secretary, B.C.A.C., Group B, c/o The Institution of Electrical Engineers, Savoy Place, London, W.C.2.

The complete text of a Press notice about the Group B meeting on the 20th December will be published in next month's issue.

HARWELL REACTOR SCHOOL

The Harwell Reactor School is increasing the number of courses which it holds each year. In 1958 there will be four standard courses and two courses for senior technical executives. The dates of the standard courses are: 13th January to 8th May; 14th April to 1st August; 1st September to 23rd December; and 27th October to 20th February, 1959. The dates of the senior technical executives' courses are 12th May to 22nd May, and 22nd September to 2nd October.

The latest date for applications is three months before each course begins. Further details may be obtained from

The Principal, Reactor School, Atomic Energy Research Establishment, Harwell, Didcot, Berkshire.

A WORLD TOUR BY THE PRESIDENT

MARCH–APRIL 1958

The President, together with the Secretary and Mrs. Brasher, will be leaving London by air on the 28th February 1958, the day after the Annual Dinner of The Institution, to attend the Commonwealth Engineering Conference in Australia and the Conference of Engineering Societies of Western Europe and the United States of America (EUSEC) in New York. Their first stop will be Baghdad, where on the 1st March a meeting of members of the Iraq and Persian Gulf Joint Oversea Group is being arranged. They may also meet members of the Group at Basra or Kuwait, but this depends on air services available at the time. Under present arrangements they depart from Basra on the 5th March, though the date may be changed if additional air services are introduced. Their flight takes them to Karachi, and then on to Bombay, where they arrive in the early hours of the 6th March.

The President and the Secretary had originally planned that they would both meet members in Bombay and Colombo, but the available air services have made it necessary for them to separate. The President will remain in Bombay until the afternoon of the 9th March, while the Secretary goes on to Colombo. They join forces again in Calcutta.

During his stay in Bombay Mr. Goldup will visit members of the Bombay Oversea Committee, who are arranging a fuction at which he will be able to meet the general body of local members. Similar arrangements are being made in Colombo for the Secretary to meet the Branch Committee and local members, and for him to meet officers of The Institution of Engineers, Ceylon. He leaves Colombo early in the morning of the 8th March, and after a night stop in Madras, rejoins the President in Calcutta on the 9th March, for a two-day visit to the city.

The Council's Oversea Representative for India, in conjunction with the Calcutta Branch Committee, is arranging meetings in Calcutta, at one of which it is hoped that local members of The Institution of Engineers, India, will also be present.

The representatives of The Institution of Mechanical Engineers who are attending the Conferences will be in Calcutta on the same dates, and the two parties, the Mechanicals' and our representatives, fly together to Singapore on the 11th March; after a short stop there, they fly on to Kuala Lumpur, where they will meet the representatives of The Institution of Civil Engineers. A three-Institution function is being arranged in Kuala Lumpur by the Committee of the Singapore/Malayan Joint Oversea Group. The whole party—Civils, Mechanicals, Electricals—will probably travel to Singapore again on the Friday, and a function for local members will take place in Singapore before the representatives leave for Australia on the Sunday evening.

Meetings of the Commonwealth Engineering Conference will take place in Melbourne, Sydney and Canberra. Arrangements are being made for the President and Secretary to meet local members in Melbourne and Sydney, where there are Oversea Committees. At one time they hoped that they would be able to visit other Oversea Committees and members in Australia, but the tight programme for the Conference now makes this unlikely.

On or about the 5th April, the whole party of representatives will be travelling to New Zealand: they will be visiting Christchurch, Wellington and Auckland, and there will be opportunities in each place for members to meet the President and Secretary. On the 17th April, the party departs for Vancouver; a day will be spent in Honolulu *en route*.

The President hopes to be able to meet members in Vancouver, where he will be staying for about two days. He and the Secretary move on by train to Calgary, probably on the 22nd April. From there they fly to Toronto, arriving probably on the 24th April, and a meeting with members there is planned for the 25th April. The next day they fly to New York for the EUSEC Conference beginning on the 28th April.

The President will return to England a few days after the end of the Conference, but if other engagements permit, the Secretary may stay on to attend the Annual Meeting of the Engineering Institute of Canada in Quebec.

THE BENEVOLENT FUND

The Court of Governors are pleased to acknowledge contributions to the Benevolent Fund totalling £4, sent by an anonymous donor.

THE INSTITUTION OF ENGINEERS, INDIA

An invitation has been received from the Council of The Institution of Engineers, India, for members who may be in India at the time to take part in the 38th Annual General Meeting of The Institution, which will be held in Lucknow from the 15th to 18th February, 1958. Further details of the programme, which includes a study tour of engineering projects in Uttar Pradesh, can be obtained from the Secretary, the Oversea Representative of the Council for India, or The Institution's Honorary Secretaries in Calcutta, Bombay and Madras.

SYMPOSIUM ON ELECTRONIC WAVEGUIDES

The Microwave Research Institute of the Polytechnic Institute of Brooklyn, in conjunction with the Institute of Radio Engineers, is holding a Symposium on Electronic Waveguides from the 8th to 10th April 1958, in the Engineering Societies Building in New York. The symposium will cover the interaction of electromagnetic fields and electron or plasma beams in electronic waveguides, which are taken to include open and closed waveguide regions where there may be relative motion between electromagnetic waves and charge particles. The tentative programme is divided into five sections: Fundamental Progress Reports; Mode Theories; Noise Theories; Space Charge Waves in Open and Closed Systems; and Plasma Waves. The final programme will undoubtedly contain other topics, depending on the interests of the participants. The symposium is open to anyone interested, and those who want further information about it should approach The Secretary, Symposium Committee, Microwave Research Institute, 55 Johnson Street, Brooklyn 1, New York.

OVERSEA ATTENDANCE REGISTER

During the period 16th November to 15th December the following members called at the Institution building and signed the Attendance Register of Oversea Members:

APTE, B. M. (Bombay)
GATES, W. A. S. (Sydney)
GRANT, J. C. (Nairobi)
HEAD, S. (Basrah, Iraq)
KATZELIS, N. G. (Nicosia, Cyprus)
MACDONALD, A. N. (Montreal)
MELVILLE, D. H. (Dallas, Texas)
RETTIE, R. S. (Ottawa)
SLOANE, R. W. (Beirut, Lebanon)

A few of those at the Dinner of the Rugby Sub-Centre, including the Chairman, Mr. W. J. Carfrae, and the President

CAMBRIDGE RADIO AND TELECOMMUNICATION GROUP

The Cambridge Radio and Telecommunication Group welcomes visitors at nearly all its meetings, and at a well-attended meeting on the 3rd December 1957 some twenty members of the Group were joined by over twice as many visitors to hear Mr. Martin Ryle, himself a member of the Group, talk about the new Mullard Radio Astronomy Observatory. The meeting was held at the Cavendish, and in the unavoidable absence of Mr. N. C. Rolfe the chair was taken by Capt. N. Hiller.

Since the talk had been first arranged, the Russian satellites had appeared in the sky, and Mr. Ryle was asked to enlarge the scope of his lecture to include some account of work at Cambridge in tracking them. The lecture thus fell into two parts: first, a short description of the Mullard Radio Astronomy Observatory now nearing completion at Lord's Bridge, about five miles from Cambridge; and secondly, a report of work at Cambridge on the satellites. The speaker lucidly explained the principles of interferometer instruments and of the system of 'aperture synthesis', which allows the resolving power and the collecting area of a radio telescope to be increased without a large reflector such as that used at Jodrell Bank. In speaking of the observations on the satellites, Mr. Ryle kindled in his audience some of the enthusiasm felt by the Cambridge radio astronomers in the early days of each satellite, when the transmissions were still being received and both interference and Doppler measurements on them were possible. To those of us who think in two rather than three dimensions, the investigation of the elements of the satellites' orbits from the rather tenuous radio observations seemed a remarkable piece of expertise.

At the end of his talk Mr. Ryle kindly answered a number of questions, chiefly about the Russian satellites, and when the audience had satisfied their curiosity Captain Hiller closed the meeting by warmly thanking the speaker. Members in Cambridge were fortunate to have the privilege of hearing this talk; we must indeed hope that there will be an opportunity in the future for Mr. Ryle to describe the work of the new observatory to an audience at Savoy Place.

RUGBY SUB-CENTRE

Setting a Standard

At the first Annual Dinner of the Rugby Sub-Centre on the 21st November we had the great honour of the President's company, which undoubtedly ensured the success of the function, especially since each member had the pleasure of being personally welcomed by the President on his arrival. We were also pleased to see that Mr. T. E. Goldup was accompanied by Mr. W. K. Brasher.

Also present at the Dinner were the Member of Parliament for the Rugby Division of Warwickshire, His Worship the Mayor of Rugby, the Chairmen and Secretaries of the South Midland Centre and North Staffordshire Sub-Centre and the Chairmen of their Graduate and Student Sections. The speeches were excellent, and it was with reluctance that the cheerful gathering broke up at about 10.45 p.m. It was considered by all present that this successful first effort has set a standard for the years to come. R. W. R.

CHESTER: MERSEY AND NORTH WALES CENTRE

Mr. T. E. Goldup began his series of Presidential visits to the Centres on the 11th November 1957, when he attended the Annual Dinner of the Mersey and North Wales Centre held at the Grosvenor Hotel, Chester, under the chairmanship of Mr. T. Makin.

On this occasion he replied to the toast of 'The Institution', proposed by Lt.-Gen. Sir Otway Herbert, G.O.C. Western Command. Sir Otway discussed the significance of the Russian satellite and paid tribute to the importance of scientific and electrical services in the modern Army. He humorously recounted how, on his recent transfer of residence to this area, he had been informed that his domestic installation had been condemned by Manweb. We vividly pictured his indignation as he inquired the identity of 'this man Webb', but the General admitted that in the end this was a battle he lost.

Responding, Mr. Goldup emphasized the importance of the continuing and increasing flow of technologists and indicated the efforts of The Institution towards achieving this object.

The distinguished guests included Mr. F. Hart Davies, Deputy Mayor of Chester, Dr. J. E. Taylor, Mr. W. K. Brasher, representatives of kindred Institutions and Societies, and the Chairmen of several of our own Centres and Sub-Centres. Their health was proposed most ably and humorously by Professor J. M. Meek.

In his reply Dr. Taylor referred graciously to his industrial association with Mr. Makin, and from his further remarks we gathered that he understood the Centre was based on Chester! Bearing in mind the presence of Mr. T. Coates and remembering his oft-expressed convictions on the subject, one could conclude quite fairly that Dr. Taylor had been subjected to 'treatment'.

The Annual Dinner-Dance is to be held on the 20th March 1958 at Hulme Hall, Port Sunlight. E. W. A.

NORTH STAFFORDSHIRE SUB-CENTRE

Chairman's Address

The first meeting of the session was held at Stoke-on-Trent on the 14th October 1957. The Chairman, Mr. A. T. Chadwick, formally welcomed Mr. L. Haywood as a Corporate Member and then introduced and welcomed Mr. L. L. Tolley, Chairman of the South Midland Centre, and Mr. G. F. Peirson and Mr. H. J. Gibson, also of the South Midland Centre. Mr. Tolley said he was very pleased to be present at the start of the tenth session of the Sub-Centre and commented on its continued progress and growth of membership. He referred to the present electrical industrial revolution and the great changes in the way people work and live, which was being brought about by the continually developing electrical equipment available. While engineers should continue such development, he thought they should also study, and take a broader interest in, the effects these developments are likely to have.

Mr. Chadwick thanked Mr. Tolley for his remarks and then invited Mr. H. A. P. Caddell to deliver his Chairman's Address on *Factors affecting the Efficiency of the Retail Distribution of Electricity*. Mr. Caddell dealt in detail with the technical, economic, and human factors which had to be considered in order to attain the highest efficiency. In proposing a vote of thanks, Mr. R. W. Palmer said that most people thought the distribution engineer had a fairly simple job, but Mr. Caddell had given a clear insight into the amount of technical work and the human interest involved. As this island had the greatest telephone density and probably the greatest distribution density in the world, he was sure that if an atom bomb exploded or other such calamity occurred there would be enough wire in the country to hold it together.

Mr. Caddell expressed thanks for his election as Chairman and said it would be his privilege and pleasure to make every contribution possible to the well-being of the Sub-Centre. He thanked Mr. Chadwick for the leadership and wisdom displayed during his chairmanship and expressed everyone's regret that he had been called away for so long during his term of office. Mr. Tolley presented a copy of *The History of The Institution* to Mr. Chadwick as a memento of his year of office. In his acknowledgment, Mr. Chadwick said it was a long time since he last received a book prize; it had been one by Charles Dickens, and it had put him off Dickens ever since.

In conclusion, members were reminded of the advantages of membership of the specialized sections. The proceedings were followed by refreshments and a conversazione.

Rectifier Locomotives

At the meeting at Stafford on the 28th October, under the chairmanship of Mr. H. A. P. Caddell, two closely related papers were read: *Electrical Equipment for Rectifier Locomotives* by H. B. Calverley, E. A. K. Jarvis and E. Williams, and *Circuit Calculations for Rectifier Locomotives and Motor Coaches* by T. E. Calverley and D. G. Taylor. The first paper was read by Mr. H. B. Calverley and the second by Dr. T. E. Calverley; Mr. D. G. Taylor assisted in replying to the discussion. The papers gave a most interesting survey of this topical subject, the first discussing the various ways in which the characteristics of transformers, rectifiers, d.c. motors and control systems can be chosen to form a complete equipment, and the second indicating the limitations of present theory when applied to the large single-phase rectifiers now required, and describing a new approach to their problems.

The discussion was opened by Mr. K. Phillips and ranged over many aspects of the problems involved, but shortage of time prevented more than five members from speaking. Mr. R. W. Palmer proposed a vote of thanks to the authors and congratulated them on dealing so adequately with an interesting but rather difficult subject.

Under New Management

The Joint Annual Dance was held at the Crown Hotel, Stone, on the 22nd November. In past years the arrangements for the Dance were made by the Sub-Centre Committee, but on this occasion everything was left in the hands of the Graduate and Student Section Committee, who, while broadly following the same lines, introduced a few innovations of their own. It is not known whether this was the cause, but it was gratifying to see a larger proportion of Graduates and Students attending. This has now become firmly established as 'Ladies' Night' and the function takes the form of a very friendly and enjoyable social evening. It was pleasant to have the Chairman of the South Midland Centre, Mr. L. L. Tolley, and Mrs. Tolley with us on this occasion. Prizes won in the very amusing elimination dances were graciously presented by Mrs. Caddell. Mr. Caddell, Sub-Centre Chairman, congratulated the Graduate and Student Section Committee and thanked their Chairman, Mr. A. Davies, who acted as Master of Ceremonies, and all who had helped to ensure a most successful evening. L. G.

SCOTTISH CENTRE

A Small World . . .

The Annual Dinner-Dance of the Scottish Centre was held in Glasgow on the 19th November, when a record number of almost 300 members and guests assembled under the chairmanship of Mr. E. O. Taylor. The chief guest was Mr. Andrew Stewart, Controller of the B.B.C. in Scotland, who, in proposing the toast to The Institution, referred to the close ties between The Institution and the engineering staff of the B.B.C. The President of The Institution, whom we were very glad to welcome to Glasgow, replied in a delightful and amusing speech which set a suitably light-hearted standard for the evening. In handing over the Hutchison-Winning Golf Trophy, won this year by Mr. P. McNee, Mrs. Taylor referred not only to golf-widows but also to 'amp-widows', resulting from the increasing scope of Institution and other electrical activities. The toast to the guests was proposed by Dr. A. J. Small, of the University of Glasgow and Chairman of the South-West Scotland Sub-Centre, and replied to by Professor J. Small, of the same university and President of The Institution of Engineers and Shipbuilders in Scotland. Mr. R. J. Rennie, Senior Vice-Chairman, brought the formal proceedings to a close by proposing a toast to the Chairman, after which dancing was enjoyed until midnight.

. . . and a Large Country

The first of this session's District Meetings was held at Inverness on the 21st November, when Mr. R. J. Rennie read the paper prepared by himself and Mr. J. S. Pickles on their *Visit to Russia*. In the absence, due to illness, of Professor E. G. Cullwick, Chairman of the North Scotland Sub-Centre, the proceedings were opened under the chairmanship of Mr. W. O. Fowlie, who welcomed to the meeting Mr. E. O. Taylor, the Centre Chairman, and invited him to take the chair for the evening. In accepting this, Mr. Taylor referred

to the especial need for District Meetings in such a widespread area as that of the Scottish Centre, and expressed the hope that, in view of the success of the Inverness meetings (seventy-nine persons being present on this occasion), it would be possible to hold others even farther afield. The lecture and the coloured slides taken mainly by Mr. Rennie himself, the Russian film of the visit and the discussion were much enjoyed by those present, and the thanks of the Centre were expressed to Mr. J. S. Oliver, who made the local arrangements.

Fiery Meeting

A District Meeting was held for the first time in Dunfermline on the 27th November, the chair being taken by Mr. W. T. Allcock. Mr. L. Gosland read his paper on *Age and the Incidence of Fires in Electrical Installations*. The subsequent discussion raged for a considerable time and had finally to be extinguished by the Chairman in order to enable the author to catch his train. The meeting was attended by thirty-seven members and visitors, many of the latter being from the Dunfermline and District Electrical Society, of which Mr. Allcock is President.

Kelvin Lecture goes Home

At Edinburgh on the 3rd December, Dr. W. B. B. M. Sutherland delivered, before a very appreciative audience, his 1957 Kelvin Lecture on *Infra-Red Radiation*. In introducing Dr. Sutherland, Mr. E. O. Taylor, the Centre Chairman, mentioned that this seemed to be the first time that the Kelvin Lecture had been delivered in Scotland, and he suggested that it might be appropriate for subsequent Kelvin Lectures to be delivered in Lord Kelvin's native land as well as in London. E. O. T.

LONDON REPORT

ORDINARY MEETING

The Willis Jackson Report

A committee, under the chairmanship of Dr. Willis Jackson, was constituted in the autumn of 1956, 'to consider in the light of the White Paper on Technical Education [published in February 1956] the supply and training of full-time and part-time teachers for technical colleges, and to make recommendations'. The Report of the Willis Jackson Committee was discussed at the Ordinary Meeting held on the 7th November 1957, which was attended by, among others, the Minister of Education, Mr. Geoffrey Lloyd.

The Report was complementary to the White Paper, which, in summary, recommended means for providing:

(*a*) An increase to 15000 from the 1955–56 figure of 9500 in the annual output of students from advanced courses, visualized mainly as full-time and sandwich courses.
(*b*) An increase to 700000 from the 1955–56 figure of 355000 in the number of students attending part-time day courses during working hours.

The building programme to achieve these objects will cost about £100m; student-hours of teaching will be increased about 50 per cent over the figure for the 1955–56 session, but these improved facilities are dependent ultimately on the teaching staff available.

In the 1955–56 session there were about 11000 full-time teachers, not including 391 Principals and Vice-Principals, and some 40000 part-time teachers. The increase, during the preceding three years, of full-time and part-time teachers, was 770 and 2000 per annum respectively. This is an encouraging increase, but quite insufficient for future needs. An increase is required of full-time teachers from 11500 in 1955–56 to 18600 in 1960–61, and of part-time teachers from 39000 to 47000—increases of 64 per cent and 20 per cent respectively. The greater increase in the number of full-time teachers is due to the increasing emphasis of full-time and sandwich-course work and the extension of part-time day as against evening study.

The more difficult aspect of the problem is to increase the number of full-time teachers, since making good the annual loss—death, retirement and transfer to other kinds of employment—requires an average annual recruitment of full-time teachers of 2300 per annum over the five-year period.

How can we obtain this high recruitment rate? Fundamentally, we require a new co-operative relationship between industry and the technical colleges, and the willingness of industry to release technologists for day-time teaching work. This is particularly difficult at a time when industry is short of technologists, but the sacrifice must be made.

In the second place, teaching must be made more attractive, and the Committee suggest that every effort should be made to reduce the amount of actual teaching at present required of many teachers. They suggest, moreover, the more generous provision of clerical, laboratory and research assistance; a better deployment of highly qualified staff; and opportunities for research and consulting work for which the teacher should be allowed to retain honoraria and fees. Teachers should be encouraged and assisted to return to industry for 'refresher' experience; and should be encouraged to attend short technical courses and conferences with financial help for expenses where appropriate.

In the third place, there should be improved facilities for the training of technical teachers. The position in the 1955–56 session was that, of 11000 full-time technical teachers, about a third received teacher training, the majority of these in subjects other than technology. There are facilities for teacher training at Bolton, Huddersfield and the Garnett College in London, which together accommodate about 300 students. It is recommended that the number of places be increased at once from 300 to 500 with a further increase to 700 places in due course, and for this purpose a fourth training college should be established in the Midlands. Better rates of grants should be provided for students taking full-time courses of pre-service training, and certain teachers taking a full-time course of study for a year or a term should be seconded on full salary, and receive free tuition and a grant to cover travel expenses and additional costs of maintenance. Each college should have a strong governing body represented on industry, technical colleges, local education authorities and universities.

A variety of training courses should be established for pre-service and in-service students, and in addition there

should be a residential staff college to enable senior college staff to study teaching, administrative and technical problems, in conjunction with representatives of industry, universities, Government establishments and schools. Finally, the Committee recommend the establishment of a Standing Advisory Committee on the Supply and Training of Teachers for Further Education.

The Report was presented at the Institution meeting by Dr. Willis Jackson, and the discussion was opened by the Minister of Education, who made a complimentary reference to The Institution's work on technical education. Unfortunately, as a nation, we had scandalously neglected technical education for generations, and the new situation demanded a rapid, determined development. It called for a joint contribution by all concerned, and the Minister emphasized the importance of industry's part in this urgent matter.

The discussion was continued by Mr. E. G. Godfrey (*President, Association of Teachers in Technical Institutions; Borough Polytechnic*); Dr. J. E. Richardson (*Director of Education, The Polytechnic*); Mr. L. J. Davies (*Director of Research and Education, British Thomson-Houston Co.*); Mr. F. B. P. Browning (*Assistant Education Officer, Warwickshire County Council*); Mr. O. W. Humphreys (*Director, Research Laboratories of the General Electric Co.*); Mr. H. S. Barlow (*Head of Physics and Mathematics Department, South East Essex Technical College*); Mr. Maynard M. Boring (*Member of the American President's Committee on Engineering Manpower; General Electric Co., U.S.A.*); Alderman J. W. Brown (*Chairman of Council, Association of Technical Institutions*); Mr. C. Jameson (*Principal, Garnett College*); Mr. Austen Albu, M.P.; Sir Hugh Linstead, M.P.; Mr. A. A. Part (*Under-Secretary, Ministry of Education*).

It was a tribute to the work of the Committee that speakers found few grounds for criticism of the Report. Their contributions were directed mainly to underlining the importance of the Committee's conclusions and showing by the recounting of examples how certain of the proposals had already been put into operation in one part of the country or another. An excellent example quoted was that of the Rugby Technical College—where local industry had co-operated fully with the work of the college in releasing senior staff for day-time teaching, and, moreover, provided facilities for the full-time college staff to obtain 'refreshers' of industrial experience. A more graphic example was given by Mr. Boring on co-operation in the United States between industry and technical colleges: his company, with 37 000 professional employees, retained as many as 186 university professors on a consulting basis, and found the scheme more than paid for itself. He recalled instances of the systematic and widespread release of industrial technologists for teaching, and referred also to the success of recent experiments in the teaching of science and mathematics by closed-circuit television, where it was found that there was, among the students, better receptivity and better retention of the lecture material.

Other speakers referred to the importance of the college library as the centre of private study and information for the industry; to the possibility of a greater degree of transfer from research laboratories to technical colleges, where in middle life a research worker could find a new and rewarding career to which he could bring the most valuable groundwork of experience; and to the training of teachers, not only in teaching and training colleges, but on the job.

One speaker described the problem as being one of space rather than of teachers—there might, therefore, be a shortfall in the number of students in 1960–61 and the number of teachers required might be less than the report suggests. This was not the view of other speakers, however, although there was general agreement on the urgency of the building programme. It was reassuring, therefore, to hear that there would be no cut in the Government's published plans for building technical colleges. It was encouraging also to learn that the Minister had agreed to the establishment of the Standing Advisory Committee recommended in the Report.

The presentation of the Report and the ensuing discussion left the clear impression that this is a problem which must be tackled immediately. Here are the means by which the numbers of teachers may be increased to provide for the expansion of technical education for our survival as a great industrial nation; the fundamental requirement is whole-hearted co-operation between the technical colleges and industry from which so many of the additional teachers—both part-time and full-time—will have to come. C. T. M.

MEASUREMENT AND CONTROL SECTION

Three Papers on Computers

At a meeting of the Measurement and Control Section held on the 5th November, three papers on widely different aspects of digital computer techniques were read before an appreciative audience. Short reviews of the papers appear on p. 24 *et seq.*

The first, *The Design of the Control Unit of an Electronic Digital Computer*, by M. V. Wilkes, W. Renwick and D. J. Wheeler, was wittily presented by Dr. Wilkes. He described the matrix method, applied to a fully parallel computer, of dissecting a computer order into a sequence of basic operations, which has been called micro-programming, a term which he did not wish to perpetuate owing to the possibility of ambiguity. Both diode and core matrices may be used in this method of control-unit design, and in Edsac II an 8×6 core matrix is at present in use. Dr. Wilkes claimed for this design philosophy that it is systematic and consequently easier to pursue than other more *ad hoc* methods. Subsequent speakers generally agreed with him.

The second paper, *A Decimal Adder using a Stored Addition Table*, by M. A. Maclean and D. Aspinall, was presented by Mr. Maclean. He described how, following a suggestion by Dr. Svoboda, a decimal adder had been built using a variety of bi-quinary, binary-coded decimal number representation. This representation is obtained by combining the binary forms of the residue modulo 5 and modulo 2 for each decimal integer. Its advantage lies in the absence of a carry between the two parts of an integer in the operation of addition, so that rather faster operation may be obtained from inherently slow circuits than would otherwise be the case. Mr. Maclean described in detail the design of an adder using slow transistors and magnetic cores, where this advantage permitted operation at 50 kc/s.

The last paper, *An Accurate Electroluminescent Graphical Output Unit for a Digital Computer*, by T. Kilburn, G. Hoffman and R. E. Hayes, was presented by Mr. Hayes. As one contributor to the discussion pointed out, this paper was of special interest because it was probably the first published application of electroluminescence to the computer art. The display unit described accepts directly a digital input giving the x and y co-ordinates of the point to be displayed; it secures very high accuracy and repeatability since every possible point is defined by the intersection of a pair of very

accurately placed orthogonal conductors, between which the photoluminescent phosphor is sandwiched.

Opening the discussion, Mr. W. S. Elliott disclaimed any intention of providing verbal fireworks, regardless of the date. He pointed out that, since no more papers dealing with digital computers were to be given in the present session, the papers that had been presented should be regarded as showing what advances had been made in the art since the Convention on Digital-Computer Techniques in April 1956, and should be judged accordingly. Mr. Elliott complimented Dr. Wilkes on the elegance of the methods he had described, and asked for any comments regarding their application to fully serial or parallel-bit serial-character machines. He regretted that the second paper had not made any extensive comparisons with other stored-addition-table methods and suggested that magnetic cores with many turns might not retain the reliability expected. He asked whether the residue-number system could be used throughout a machine. Turning to the last paper, he questioned the value of the extreme accuracy which the authors reported.

This point was taken up by Dr. D. J. Truslove, who also pointed out the disparity in speed between a fast modern computer and an output unit accepting only one point every 30 millisec.

The suggestion was made by Mr. D. M. Taub, referring to the first paper, that a saving in equipment would occur when diode matrices were employed if a counter was included in the sequencing device. Mr. K. L. Smith, on the other hand, proposed that core shift registers of the type described by Wang could reduce the equipment needed in a rather similar way, if core circuits were favoured.

Mr. D. V. Willis suggested that the value of more sequential units over purely general matrix arrays could best be found by a comparison of the number of micro-steps involving a jump with those which led directly on.

Mr. J. H. Briggs commented on the potentialities of an electroluminescent matrix display as a television viewing device, while a word of warning was given by Mr. T. B. Tomlinson on the difficulties of using evaporated phosphor layers which would require subsequent heat treatment to improve crystal structure.

Dr. Wilkes, in reply to Mr. Elliott, stated that he believed a small serial computer had been made on the lines described. However, in a serial machine, one of the matrices would be used to gate the outputs from a waveform generator. He felt that any major departure from the complete generality of the matrix, as suggested by Messrs. Taub and Smith, would add extra complications tending to nullify the attempt at sequential organization.

Mr. Maclean explained that a multiplier using residue representation would be extremely complicated and that any extension to a base other than ten would involve a 'fearsome decoding problem'. He could not agree to the criticism of cores with many turns.

Both Dr. Kilburn and Mr. Hoffman rose to the defence of their electroluminescent display, the former making the point that up to 30% of his own computer's output ended up in graphical form, and adding that if Dr. Truslove would journey to Manchester he could have a 1 000-point graph for a third of the price that Dr. Truslove himself had quoted. Mr. Hoffman said that the accuracy was obtained at no extra cost, and that speed could undoubtedly be much increased. He finished by issuing an invitation to all interested to see a demonstration of the display unit at Manchester University, since it was not practicable to give one at the present meeting.

A vote of thanks to the authors proposed by the Chairman, Mr. H. S. Petch, was carried with acclamation. I. W. M.

RADIO AND TELECOMMUNICATION SECTION

Printers versus Plumbers

At the meeting of the Radio and Telecommunication Section held on the 13th November 1957, Mr. J. M. C. Dukes presented three papers on microstrip techniques: *The Application of Printed-Circuit Techniques to the Design of Microwave Components*; *Broad-Band Slot-Coupled Microstrip Directional Couplers*; and *Re-entrant Transmission Line Filter Using Printed Conductors*. A short review of these three papers appears on p. 22.

Mr. Dukes described a relatively new technique for the construction of microwave components by printing methods, which, he considered, had some notable advantages and perhaps a few disadvantages compared with conventional methods using rectangular waveguides with flanged connexions —popularly known as 'plumbing'.

The microstrip techniques described in the papers were essentially metallic-strip transmission lines in various forms, sometimes deposited by photo-mechanical methods on thin dielectric boards.

The author outlined various methods that could be used for the design of microwave components such as filters, hybrids and directional couplers, pointing out how the special characteristics and limitations of strip lines required a different approach from the design of components in rectangular waveguides.

The advantages claimed for microstrip were those of lightness, compactness, reproducibility, and suitability for quantity production at low cost; the chief disadvantages were the limited power-handling capacity, the lack of precise characteristics and certain difficulties of measurement.

The discussion, which was very effectively opened by Mr. L. Lewin, proved to be a battle between the 'printers' and the 'plumbers', neither side giving or receiving much quarter. In reviewing the likely applications of microstrip techniques, one speaker drew attention to the possibilities of microstrip for cheap compact microwave-link equipment operating at frequencies above 10 Gc/s and providing a small number of telephone circuits. Such an equipment would use printed-circuit techniques, not only for the microwave components, but also for the intermediate-frequency amplifiers and time-division-multiplex channelling equipment.

When the dust of battle had subsided, it was generally realized that it was unlikely that printed-circuit microstrip techniques would supplant conventional waveguide techniques for all applications, but it would most likely be found useful in a range of applications where lightness, compactness and suitability for quantity production were more important than great precision and the ability to handle high powers. However, it was agreed by all that Mr. Dukes had made a notable and valuable contribution to the art of microstrip design, which would greatly facilitate future development. W. J. B.

Pleasure versus Perfection

The technology of sound reproduction seems nowadays to become increasingly subjective. The consulting engineer for a concert hall, the designer of a sound reproduction system for an auditorium, the 'hi-fi' enthusiast entertaining his

friends are all less concerned with optimum reverberation times, flat frequency-response curves and correct volume levels than they probably were fifteen years ago. Today the emphasis, as on the Light Programme, is on giving the public what it wants, and most engineers in installing domestic high-fidelity equipment would aim at the most pleasing result rather than the most faithful reproduction. But in the way of many of the best things in life, the 'most pleasing result' in the home is a developed taste, particularly for those who have spent years listening to music reproduced by an inexpensive radiogramophone. So the 'hi-fi' enthusiast must be prepared, like the Third Programme, to do some educating, and he probably begins with his family. The subjective emphasis was prominent in the discussion at the Informal Evening arranged by the Radio and Telecommunication Section on the 28th October 1957, under the title 'Domestic High-Fidelity Reproduction'. Probably few members of the Section are concerned professionally with this application of electrical engineering, but the large audience in the theatre, reminiscent of that at an Ordinary Meeting, testified that there are many who are interested in it.

Speaking from the dais behind an impressive army of loudspeakers and other apparatus for the demonstration he gave, Mr. J. Moir set the turntable spinning with a breezy account of what could and could not be done successfully in the home. He stressed that what sounded all right in a large hall seldom did in a small room. Both the reverberation times and the reverberation-time/frequency curves were different, and the upshot was that for maximum pleasure one normally required less than the full frequency and volume ranges in the small room. Somerville and Brownlees had indeed shown in 1949 that the preferred volume level in a concert hall and a room differs by 25 phons. (It was surprising to hear that the Americans on the average liked lower peak volume level than the British.) Mr. Moir described the tests by Chinn and Eisenberg and by Olson to show that people liked hearing music in effect through a comparatively narrow band-pass filter, unless they were told that they were listening to the full range of frequencies, when their preference shifted to that. So far as he knew, nobody had yet made an engineering demonstration showing that people liked wide-range response in a small room. Moreover, as illustrated by one of Mr. Moir's demonstrations at the meeting, in an average orchestral piece of music there were only occasional short bursts of frequencies higher than 10 kc/s.

Mr. Moir stressed the value of the size of loudspeakers—both in dimensions and power-handling capacity—and the inefficiency of the widely used small moving-coil type that often is to be found in cheap commercial reproducers euphemistically dubbed 'hi-fi'. But two synchronized loudspeakers were hardly any larger acoustically than one, owing to the 'Haas effect'—when the ear is listening to a pattern of sound it cannot hear the same pattern of sound from a different source if the second pattern follows the first almost instantaneously. This effect was demonstrated convincingly, though not quite convincingly enough for one speaker in the discussion who appeared to have heard both loudspeakers all the time they were switched on together. No doubt he is not troubled by the problem of which way to turn which confronts most people in a large hall when they find themselves equidistant from two loudspeakers (and perhaps the lecturer as well).

Mr. Moir ended his opening remarks by considering possible future improvements in domestic sound reproduction. The development of cheaper stereophonic systems would, he felt, go a long way towards removing present defects. Curiously the loudspeaker did not come in for its usual castigation as the weakest link in the chain, though Mr. Moir thought that the polar diagrams of most designs showed much room for improvement. The use of magnetic recordings on tapes was likely to increase, for the distortion was lower than with discs, and the signal/noise ratio, though initially no higher than that obtained from a good disc, could be maintained through several hundred playings.

Mr. J. K. Webb, who followed the opening speaker, struck a 'nothing new under the sun' note. It seemed that he had opened a somewhat similar discussion at a meeting of the Radio Section in 1954, but although The Institution did not countenance the term 'hi-fi' at the time, most of Mr. Moir's points had been made on that occasion. Mr. Webb still supported them, and asked what progress had been made recently in the provision of synthetic bass—'bass without baffles'.

Captain P. P. Eckersley followed with a typically witty and enjoyable speech which ranged from opening windows to Brown Windsor soup and women engineers, and which implied in passing that its originator supported Mr. Moir's target of pleasure rather than perfection—'no good striving for perfection if you don't get there'.

But the perfectionists found a champion in Dr. L. G. Hughes, who, in an urbane and well-informed speech, attacked most of Mr. Moir's gospel. The arguments advanced might apply to sound reproduction in cinemas, but not to high-fidelity reproduction of music for a discriminating public. The acoustic engineer, thought Dr. Hughes, must reproduce as well as he could, and those who used his equipment must, if necessary, be trained to listen to music. A suitable room in which to reproduce music was a rectangular one with a ring of loudspeakers at one end and padding at the other to cut out reflection. All reverberation effects heard by the listener would then be those recorded in the original hall.

The debate continued with most speakers supporting Mr. Moir rather than Dr. Hughes. But one member simplified the whole issue by remarking that it hinged on whether you had your eyes open or shut. If you shut them you could mentally transpose yourself to the concert hall and you wanted the music reproduced as closely as possible to the original. If your eyes were open, you were confined to your own small room and your senses demanded something different in reproduction. Will the 'hi-fi' amplifier of to-morrow have an eyes-open/eyes-shut switch?

One or two speakers felt that present-day 'hi-fi' equipment was a bit unmanageable in an ordinary sitting-room and that for the sake of appearance, if nothing more, designers should concentrate on producing the same result with smaller loudspeakers. Dr. R. C. G. Williams, indeed, said he would not like to hang up one of Mr. Moir's pet electrostatic speakers in *his* house. Wittily developing the theme that a complete 'hi-fi' reproducer must be both acceptable to the public and not more than £75–100 in price, Dr. Williams explained that the television set now had priority as a piece of 'case furniture' in most homes; 'hi-fi' equipment occupied only the status of the old-fashioned radiogramophone in the days when a piano was the pride of the room.

Mr. Moir gave cheerful and succinct replies to the speakers at the end of their contributions, and when most of the audience were beginning to feel that it was time to go home and play a record, the chairman, Mr. G. Millington, brought the meeting to a close with a vote of thanks to the opening speaker—in which he indicated that there was still something to be said for making one's own music.

C. T. I.

Representatives of The Institution on Other Bodies

The following is a list of representatives of The Institution on other bodies with the dates on which they were appointed

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BLACKBURN TECHNICAL COLLEGE ENGINEERING ADVISORY COMMITTEE
H. Shackleton, M.SC. (6.12.56)

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ENGINEERING TRADES ADVISORY SUB-COMMITTEE
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BRADFORD INSTITUTE OF TECHNOLOGY
GOVERNING BODY
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BRISTOL UNIVERSITY
COURT OF THE UNIVERSITY
W. Hill (31.3.49)

BRITISH ASSOCIATION FOR COMMERCIAL AND INDUSTRIAL EDUCATION
Chairman of the Education and Training Committee (26.4.56)
Secretary of The Institution (26.4.56)

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GROUP A (ENGINEERING APPLICATIONS)
J. F. Coales, O.B.E., M.A. (7.11.57)
R. C. G. Williams, PH.D., B.SC.(ENG.) (7.11.57)

GROUP B (BRITISH GROUP FOR COMPUTATION AND AUTOMATIC CONTROL)
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W. Bamford, B.SC. (12.9.57)
Interim Steering Committee
W. Bamford, B.SC. (12.9.57)
J. F. Coales, O.B.E., M.A. (12.9.57)

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(Deputy, the Secretary of The Institution—5.2.53)

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SUB-COMMITTEE ON ELECTRICAL NOMENCLATURE AND SYMBOLS—TYPES OF ENCLOSURE (ELE/9/8)
S. J. Emerson (20.5.54)

PANEL ON INTERNATIONAL VOCABULARY OF THE I.E.C. GROUP 25—DISTRIBUTION OF ENERGY (ELE/9/10/25)
T. G. N. Haldane (26.4.56)
(Deputy R. S. Orchard, M.A.)

COMMITTEE ON ELECTRICAL SWITCH AND CONTROL GEAR (ELE/10)
*J. A. Broughall, B.SC.(ENG.) (7.3.57)

SUB-COMMITTEE ON SWITCHGEAR FOR DOMESTIC AND INDUSTRIAL DUTY (ELE/10/2)
Appointment pending

PANEL ON SMALL AUTOMATIC OVER CURRENT SWITCHES (ELE/10/2/1)
H. W. Swann, O.B.E. (19.5.55)

SUB-COMMITTEE ON SWITCHBOARDS (ELE/10/10)
*T. M. H. Stubbs (7.3.57)

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Further appointment pending

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TECHNICAL COMMITTEE ON ELECTRIC FANS (ELE/28)
A. S. Carr, B.SC. (5.11.53)

TECHNICAL COMMITTEE ON RADIO INTERFERENCE SUPPRESSION (ELE/32)
G. O. Watson (22.6.44) (Representing the Ship Electrical Equipment Committee)

PANEL ON ABATEMENT OF INTERFERENCE AT HIGHER FREQUENCIES (ELE/32/–/1)
A. J. Biggs, PH.D., B.SC. (6.12.56)

SUB-COMMITTEE ON RADIO INTERFERENCE FROM TROLLEYBUSES AND TRAMWAYS (ELE/32/3)
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Sir Archibald J. Gill, B.SC.(ENG.) (6.11.47)
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TECHNICAL COMMITTEE ON EARTHING CLAMPS (ELE/45)
*H. W. Grimmitt, C.B.E. (12.1.50)

TECHNICAL COMMITTEE ON CAPACITORS (ELE/46)
*P. R. Coursey, B.SC.(ENG.) (3.12.53)
R. C. G. Williams, PH.D., B.SC.(ENG.) (21.4.49)

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A. J. L. Whittenham (16.9.54)

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C. D. Wilkinson (5.2.53)

TECHNICAL COMMITTEE ON CONSUMER SUPPLY CONTROL UNITS (ELE/57)
H. C. Spence (31.3.55)

TECHNICAL COMMITTEE ON INSTRUMENT TRANSFORMERS (ELE/59)
G. F. Shotter (22.2.34)

TECHNICAL COMMITTEE ON POWER RATING OF H.F. HEATING EQUIPMENT (ELE/66)
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H. Willott Taylor (11.5.39)

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SUB-COMMITTEE ON MEDIUM-VOLTAGE AND LOW-VOLTAGE FUSES (ELE/78/1)
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G. O. Watson (8.11.56)

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E. E. Hutchings, B.SC.(ENG.) (25.4.57)

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F. Byrne (7.11.57)

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A. K. Clyde (25.4.57)

COMMITTEE ON AIRCRAFT LAMPS AND LAMPHOLDERS (ACE/5/2)
A. K. Clyde (25.4.57)

COMMITTEE ON AIRCRAFT ELECTRICAL CABLES AND ACCESSORIES (ACE/6)
D. B. McKenzie, B.SC. (25.4.57)

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C. S. Hudson, PH.D., B.SC. (25.4.57)

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V. A. Higgs, B.SC. (25.4.57)

COMMITTEE ON AIRCRAFT SWITCHGEAR (ACE/43)
V. A. Higgs, B.SC. (25.4.57)

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T. Somerville, B.SC. (20.5.54)

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[Deputy: E. W. Ayers, B.SC.(ENG.) (5.11.53)]

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TECHNICAL COMMITTEE ON AUDIOMETERS (ACM/4)
J. S. Forrest, D.SC., M.A. (18.9.47)

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T. Somerville, B.SC. (16.9.48)

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*E. J. Sutton (12.5.49)
Further appointment pending

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Chairman: M. S. BECK, M.SC.
Hon. Secretary: J. A. GREEN, 33 Gunnergate Lane, Marton-in-Cleve... Middlesbrough.

Codes of Practice Council

(*continued from p. 62*)

CODE DRAFTING COMMITTEE ON CLIMATE PROOFI... OF ELECTRICAL EQUIPMENT (ELCP/23)
Chairman: B. Donkin, B.A.

CODE DRAFTING COMMITTEE ON MAINTENANCE ... CONTROL GEAR (ELCP/24)
Chairman: S. J. Emerson, M.ENG.
Institution nominee: R. A. Marryat, B.SC.(ENG.) (nominated by ... Utilization Section)

CODE DRAFTING COMMITTEE ON MEASUREMENT A... ABATEMENT OF RADIO INTERFERENCE IN AIRCRA... (ELCP/25)
Chairman: N. G. Anslow.

CODE DRAFTING COMMITTEE ON LOADING OF TRANSFORMERS (ELCP/26)
Chairman: H. G. Bell, M.SC.TECH.
Institution nominees:
H. G. Bell, M.SC.TECH. (nominated by Supply Section).
W. S. Lovely, B.SC. (nominated by Utilization Section).

CODES OF PRACTICE COMMITTEE FOR MECHANI... ENGINEERING (MECP/–)
Institution nominee: F. H. Mann (24.6.54).

CODE DRAFTING COMMITTEE ON GUARDING OF MACHINERY (MECP/4)
Institution nominee: F. H. Mann (1.3.56).

CODE DRAFTING COMMITTEE ON OIL FIRING INSTALLATIONS AND CONVERSIONS (MECP/6)
Institution nominee: H. E. Baker (7.2.57).

CODES OF PRACTICE COMMITTEE FOR BUILDINGS ... (BLCP/–)
Institution nominee: Forbes Jackson (29.4.54).

CODE DRAFTING COMMITTEE ON DAYLIGHT, SUNLIGHT, AND ARTIFICIAL LIGHT (BLCP/9)
Institution nominee: W. R. Stevens, B.SC. (31.3.55).

CODE DRAFTING COMMITTEE ON LIFTS, HOISTS A... ESCALATORS
Institution nominees:
L. S. Atkinson (15.4.46). H. W. Fulcher (2.12.43).

CODE DRAFTING COMMITTEE ON MECHANICAL REFRIGERATION
Institution nominee: K. J. R. Cocke, B.SC.(ENG.) (4.3.48).

CODE DRAFTING COMMITTEE ON OPTICAL PROJECTION EQUIPMENT FOR SCHOOLS
Institution nominee: V. M. Roberts, B.SC. (8.8.48).

CODE DRAFTING COMMITTEE FOR INDEPENDENT FIRES
(formerly convened by the Royal Institute of British Architects)
Institution nominee: J. I. Bernard, B.SC.TECH. (16.1.47).